AN INTRODUCTION TO EXPERIMENTAL PSYCHOLOGY

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PREFACE TO THE SECOND EDITION

In this book I have tried to give an introduction to the study of experimental psychology. I have selected especially those topics which are of most immediate interest to the student of educational problems.

Practically all the experiments described can be carried out without any apparatus except such as can easily be made with pen and paper. There is an unfortunate impression abroad that experimental psychology necessarily involves complicated and expensive apparatus. For some types of experiments this is of course the case. But most of the experiments which are of the greatest interest and value for the student, and especially for the student of educational psychology, have no such need.

In the course of many years' experience in teaching experimental psychology to students in Universities and in a Training College, the writer, like others in similar positions, felt the lack of a suitable textbook. The crowded time-tables of the modern University or Training College do not as a rule admit of a long course in experimental psychology, and during the hours which are available it is desirable that the students should be occupied, as far as possible, in the actual carrying out of experiments in class under the oral instruction of the teacher, or in discussing their results. The dictation of elaborate notes as to the full significance of the methods

and results of the experiments, and of the theory underlying them, may leave inadequate time for the carrying out of the experiments themselves. Yet without some supplement of oral instruction the most careful student may fail to master the problems at issue. Given a suitable hand-book, the student's own note-book can be kept for the results of the actual experiments in which he takes part, and for his observations upon his own mental processes and characteristics.

Most of the experiments described here are such as have been found suitable for classes of from ten to sixty or seventy students.

I venture to suggest that the book may also be useful to students who are undergoing a course in general psychology but who are receiving no instruction in experimental psychology. The importance of some experience of experimental work as a supplement to the study of theoretical psychology is now widely recognised by the highest authorities. Some indeed contend that the study of psychology should begin with a course in experimental psychology.

The special value of experimental psychology for teachers will be more fully discussed in the introductory chapter.

No text-book can take the place of a living teacher, yet it is hoped that this book will be of value to the private student. He should be able to carry out all the experiments here described in his own room, and, after gaining an intelligent grasp of the principles and methods discussed, he will be able to apply many of them also in the

schoolroom, with results interesting to himself, and very illuminating as regards the mental characteristics of his pupils. Anything of this nature which helps to keep a teacher from becoming a slave of routine, and which enlivens his interest in the mental life of each individual pupil, is to be welcomed as a means of raising the whole level of his work.

I have tried to avoid assuming a previous knowledge of psychology, but it is presumed that the student will be studying some work on general psychology. Without this many points must necessarily remain obscure. Frequent suggestions for appropriate reading will be found throughout this book.

For the second edition the book has been considerably enlarged, and I have completely revised it in the light of more recent investigations. I was glad to find that after ten years of development in experimental psychology little of fundamental importance needed to be altered. Some important topics, however, have been added. These include chapters on The Psychology of Thought Processes, The Growth of Concepts, The Speed of Reading and its Improvement, Tests of Practical Ability, The Appreciation of Pictures and of Poetry, The Transference of Training; and additional experiments on Imagery, Association, Attention and Mental Tests. The new chapters are placed at the end of the book in order to interfere as little as possible with the previous numbering of experiments; but all of them, except the experiments on Thought Processes, may well be taken early in the course.

PREFACE TO THE THIRD EDITION

For the third edition this book has again been further enlarged, and revised throughout in the light of many new investigations during the last twelve years. There are now new chapters on the Accuracy of Report and Suggestion, Perception, Apperception and Imagination, Intuitive Judgments of Character or Disposition; and new experiments on Memory, Attention and the Testing of Aesthetic Appreciation. The bibliography has been considerably extended

Again the new experiments are placed chiefly towards the end of the book, but many of them may be taken earlier in the course.

My cordial thanks are due to my friend, Professor Burt, for several valuable suggestions for the new edition, and to my colleague, Mrs. F. M. Austin, for many useful emendations she proposed as the result of her experience in using the book.

C. W. V.

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INTRODUCTION.

The Value and Aims of Experimental Psychology.

1. The most definite value of experimental psychology is that it increases our knowledge of psychological facts and laws. Although the science is still young, it has already accumulated a large number of significant facts. Many of these are of importance in educational, industrial, and medical psychology, Apart from that, however, we cannot split mental life into sections and say that we, as teachers or social psychologists, are concerned with this part, but not with that. Consequently we cannot entirely separate educational or social or medical from general psychology, All these branches are partly dependent on the advance of general psychology.

For a complete science of the mind we need researches into all the various states and activities of the mental life. Thus the educator is indirectly interested in many psychological problems which at first sight appear to have no connection with his special pursuit. A better knowledge of these problems will bring him to a clearer understanding of mental process in general, and this he should be able to apply in dealing with the young minds under his special care. In some writings on educational and especially medical psychology, a lack of balance is shown because only a narrow field of psychology has been studied.

2 It must, however, be recognised that, from our present point of view, the chief importance attaches to those experimental results which have an immediate bearing upon education, These are already by no means inconsiderable, as I hope the reader will see from a further study of this book and from a perusal of works devoted especially to the results of investigations in educational and child psychology [1]

The literature devoted to new researches of this nature is steadily increasing,[2] and one of the chief values of a course in experimental psychology is that the student is thus enabled to understand such literature more easily and to appreciate it better. His training also will give him greater skill in sifting the wheat from the chaff: for it must be admitted that a good deal of work which shows faulty method and immature and hasty conclusions still succeeds in getting into print.

3. In the third place, and still more relevant to the purpose of this book, the student in actually carrying out experiments himself gains a much more vivid realisation of the nature of the mental processes involved. Systematic and repeated study of these often reveals to the student facts about his own mental life which have completely escaped the chance observations on which he has previously relied. Comparison with the results gained by others may also show him that his own mental experiences are marked by definite individual characteristics, and must not be regarded as absolutely typical.

Further, the exercise in self-observation which experi-

[1] See Bibliography.

[2] One British Journal, *The British Journal of Educational Psychology* (continuing *The Forum of Education*), and several American (e.g. *The Journal of Educational Psychology* and *The Journal of Genetic Psychology*), are largely devoted to such researches.

ment gives leads to greatly improved capacity for introspection, and this again enables one to obtain a more accurate acquaintance with one's own everyday mental life. Now it is upon this self-knowledge and upon the power of self-analysis that our understanding of others ultimately depends—even our understanding of children.

This particular value of a course of psychological experiments is especially evident with reference to those experiments (of which several examples will be found in this book) in which the student tries to put himself into a position similar to that of the child in learning.

4. Again, the widespread attention now being given to mental tests, makes it desirable that every teacher should have some first-hand knowledge of them. Now if a student would understand the real significance and value of mental tests, and if he is to judge them critically, it is desirable that he should observe the elementary processes involved in them, by going through similar tests himself. We must not assume that precisely the same processes are always involved when a child does a test as when it is done by an adult. But a student is much more likely to have some insight into the probable workings of the child's mind in tackling certain tests, after he has undergone them himself. For example, the effect of the attempt to work tests at speed is illuminating: and the varying ways in which different students attack the same problem are themselves very suggestive, and should prevent us from hasty generalisation as to the nature of the mental work involved in a test.

In many cases the experiments in this book are either identical with some used as mental tests or they involve elements involved in some mental tests. And it is well that the student should first approach the study of these in connection with a psychological topic, and as a part of

his general psychological studies, rather than in the midst of testing for special educational purposes.

5. Further, the teacher who has had some training in experimental psychology will be better fitted to carry out investigations, if only very simple ones, among the children of his own class.

A word of caution is needed here. Mental tests are much more difficult to manipulate and interpret than may appear at first, and for first-class reliable research work a long and thorough training is needed. Nevertheless a teacher with a "bent" for scientific method, who has gone through a course in experimental psychology such as that suggested in this book, may be able, through applying simple tests and experiments to his own class, to glean information about the mental characteristics of his pupils which will be of great interest to him and of no little value for his teaching work.

The teacher of the class, indeed, is in some respects in a better position to carry out certain mental tests upon his children than is the professional experimental psychologist. He knows his children well, the disturbance caused by the entry of a stranger into the class is avoided, and in so far as the material used in the experiment resembles that given in ordinary school lessons his presentation of it may be more uniformly efficient than that of the experimentalist who has had no experience in teaching children.[1]

In his own school-teaching days the present writer found such tests possible with very little interruption to class work, and the teacher may count upon his pupils entering into the novel and mysterious experiments with keen

[1] Cf. the remarks of Dr. C. Burt as to the reliability of the experimental work of school teachers in various kinds of mental tests, *Journal of Experimental Pedagogy*, Vol. I., p. 104.

interest, if they are properly approached. Doubtless the ordinary work of the class allows little time for such work. But some of the suggested tests can be done in little more than a quarter of an hour, and longer can probably be spared for some of the others if the teacher is content to attempt only one or two in the course of a term.

It may sometimes appear that a psychological research has only proved to be an elaborate and painstaking method of demonstrating the obvious. But it is often of great value to discover the reasons even for conclusions which have been previously accepted as self-evident. Furthermore, some things which have been thought to be obvious by many educationists have been shown by experiment to be false, so that it is not without value to have other equally "obvious" beliefs scientifically demonstrated.

Again, even if a certain experiment professedly deals with facts which are already known to us, the actual performance of the experiment itself is often illuminating to a surprising degree.

Finally, I should like to emphasise the fact that the chief purpose of this book is to encourage the actual participation in psychological experiments on the part of the student himself. The subsequent application of some of the experiments to school children, though of considerable interest and value, is not essential to the main purpose of the course.

Plan and Method of the Book.

In Part I. will be found detailed instructions for carrying out the various experiments, the necessary material being given here. The student should perform each experiment completely before turning to the discussion of the results of the experiment and their significance, which will be

found in the corresponding chapter of Part II. Thus Chapter I., Part II. discusses the theoretical and practical significance of the experiments of Chapter I., Part I. Chapter II., Part II. discusses the experiments in Chapter II., Part I., and so on. The chapters of Part II. also discuss the application of the experiments in school.

It has been thought well to keep separate the instructions for the experiments and the discussion of the results, as it will then be clear to the student exactly how much he must read before performing an experiment. In a few cases it is important that the student should not have even a momentary glance at the discussion of the results before doing the experiment, otherwise it will be difficult for him to avoid being influenced by suggestion. When it is desirable for the student to know the object of the experiment before doing it, the necessary information is given with the instructions for carrying out the experiment.

It is also hoped that the division into two parts will facilitate the use of the book for class purposes.

Throughout the course the student should make a special point of writing down and keeping for future reference his observations upon his own mental processes as observed in the experiments, not counting anything too trivial to be noticed. Even the apparent failures should be noted. The private student should not be disappointed if occasionally he forgets, or misunderstands at first, some part of the instructions and so fails to carry out the experiment properly. This often takes place with beginners, even in a psychological laboratory and under the supervision of an instructor. But, fortunately, if the nature of the error is detected and its corresponding effects traced, such a failure may prove as instructive as, and occasionally even more instructive than, the proper carrying out of the experiment.

It is not as a rule necessary that the experiments should

be done in the order in which they are arranged, but the experiments on Imagery should preferably be performed first and the Memory experiments should be taken in the order indicated. The experiments on the Growth of Concepts and on Thought Processes involve practised introspection, and should not come too early in the course. A useful series to begin with would be as follows: Experiments 1 and 2 (Imagery), 14, 15 and 16 (Rote Memory), 17 (The Value of a Map), 18, 19, 20 and 21 (Substance Memory), 3 (Association), 5, 6, 7 and 8 (Attention), 38 (Perception, Apperception and Imagination), 37 (Accuracy of Report),

PART I.

CHAPTER I.

IMAGERY.

Experiment I a.

Types of Images.—The whole of the instructions for this experiment should be read before the experiment is begun. It should be noted that the word image has a very wide significance in psychology. It includes not only the mental picture we get when we close our eyes and try to recall the appearance of something, but also the corresponding mental reproduction of a sound, or of a smell, or of a sensation of touch, taste, or movement.[1]

Think of a troop of soldiers marching.

(*a*) Can you get a mental picture (*visual image*) of them? Is the image clear (i) in form, (ii) in colour? Would you describe the image as very vivid, vivid, clear, only moderately clear, vague, or very vague?

(*b*) Can you hear mentally the sound of the marching, *i.e.* can you get an *auditory image*? Does the sound occur with its appropriate rhythm? Would you describe this image as very vivid—clear—etc.?

(*c*) Can you mentally recall the "feel" of marching (*motor image*)? Would you describe this image as vivid, or vague, etc.?

Try similarly whether you can get

(*d*) *A touch image* of the sensation produced by touching velvet or emery-paper;

(*e*) *A taste image*, say of an orange, or of coffee;

(*f*) *A smell image* of the coffee, or of a rose;

(*g*) *A temperature image*, of the sensation produced by the heat of a fire, or by touching ice;

(*h*) *A pain image*, of the pain of a pin-prick, or of any pain you have recently experienced.

The student should repeat the tests, using the following imagined objects for the respective kinds of imagery:—

(*a*) A house, a friend.

(*b*) The howling of the wind, a friend's voice.

(*c*) The movement of the tongue and lips in saying "God save the King," and of the fingers in writing it. (Care must be taken not to move the lips or fingers while trying to get these motor images.)

(*d*) The touch of a blanket, or of marble.

(*e*) The taste of sugar, and of salt.

(*f*) The smell of tar, and of gas.

(*g*) The heat of a strong sun, the cold of a piercing wind.

(*h*) Toothache, a burn, or the pulling of the hair.

The student should now be able to draw some conclusions as to the comparative vividness of the different types of imagery in his own case.

Experiment I B.

Control of Imagery.—(*a*) Close the eyes and get a visual image of a line. Can you increase or diminish its length at will?

(*b*) Visualise a square on a board. Can you increase or diminish its area at will? Can you expand the square on all sides similtaneously?

(*c*) Visualise a plain square. Can you picture it red, green, black at will? Can you keep it red even when other colours are thought of?

(*d*) Can you change the square into a triangle or rectangle at will?

(*e*) Can you image a picture seen? Can you construct a visual image of an imaginary scene? Compare the two as to clearness, permanence, etc.

(*f*) Can you use visual imagery to advantage in working a problem in geometry?

(*g*) Can you inhibit imagery? *E.g.* can you think of a friend, (a colour, a scene, etc.) *without* having a visual image of him (or it).

Similar tests may be done with images of sound.

Experiment II.

Facility of Imaging tested by Speed.—Read the instructions right through before starting the experiment.

If possible get a friend to time you in this experiment.

(*a*) Take the list below marked "Visual Images." See how many objects listed you can visualise clearly in one minute, ticking each off as you do so. Take care to wait until you get a clear image.

Visual Images.

dog	glove	tree
sunset	newspaper	lecture room
lemon	knife	rose
friend's face	banana	road
train	chair	blotting paper
smile	fire burning	daisy
door opening	bird	hat

(*b*) Now see how many clear auditory images you can get in one minute of the sounds suggested in the list

marked "Auditory Images." Tick each off as you get it. Take care to wait until you get a clear sound-image

Auditory Images.

bark of a dog	fly buzzing	child shouting
click of a latch	door slamming	splash in water
cough	click of teaspoon in saucer	pencil tapping on desk
friend's voice	footsteps in passage	thunder
hoot of a motor horn	bird 'cheeping'	striking of a match
laugh	train	grunt of a pig
telephone bell		sigh
clock chiming		

If you only managed about half the number in each test, take another half minute at each.

If you are much more ready at one kind of imagery the corresponding list is likely to be longer than the other at least relatively to those of other students.

For a discussion of the results of these experiments see p. 134.

CHAPTER II.

ASSOCIATION AND REPRODUCTION OF IDEAS.

Experiment III.

Cover up all the words in the list below with a piece of paper. Move the paper so that the first is exposed, and then write down at once the first word or phrase suggested by this word. Make an effort to note the very first word suggested, and do not hesitate to write that down even if it seems to have absolutely no connection with the given word. Proceed thus with each of the words in the list.

river	book	friend	bicycle
station	newspaper	house	good
ball	song	doctor	train
dog	martyr	green	town
organ	child	sadness	sea

Add any observation you can as to the exact way in which the idea occurred to you. For example, did you mentally picture the things of which you thought.

For a discussion of the results of this experiment and their significance see Part II., Chapter II., p. 137.

Experiment IV.

Association Reaction-Times.—Below is given another list of words, to be used in a somewhat similar way to that in Experiment III.

This time, however, get a partner to read out the words to you, one at a time: in response to each word say out aloud the first word that it suggests to you. Try to reply as quickly as possible. The length of time taken for you to respond to each particular word (the "reaction-time") must be measured by your partner.

This may be done by means of a stop-watch, but, failing that, the interval can be measured accurately enough for the purposes of the experiment if the partner starts counting (mentally) 1, 2, 3, 4, etc., as rapidly as possible as soon as he has read out the "stimulus" word, and notes down the number he has reached by the time you give your response. A usual rate is 4 or 5 counts to the second. But exact equality, in this respect, between different persons in a group test is not needed so long as a fairly constant pace is kept throughout the test: and this is best ensured by aiming at a maximum speed. After responding with the reaction word, the subject[1] should, if possible, say whether the reaction was pleasant or unpleasant.

If two partners have to change about in the course of the experiment they should do so half-way through the list, so that the same words are not used over again. The other half may be taken at a later sitting, or each student may prepare another list for his partner.

It is desirable that partners in this experiment should be of the same sex. Also in a class experiment the pairs

[1] "The subject" is the person on whom an experiment is performed. The person who performs the experiment upon the subject is the "operator" or "experimenter."

of students should be at a fair distance apart, so that the words spoken by others will not be audible enough to interfere. It would indeed be preferable for the experiment to be performed at home.

head	to pay	to dance
green	window	village
water	friendly	lake
to sing	father	sick
dead	to ask	pride
long	cold	to rise
punish	stem	to nurse
angry	book	to wash
needle	unjust	cow
to swim	frog	friend
voyage	to part	luck
blue	hunger	lie
woman	white	to sin
child	bread	to take care
rich	lead pencil	tree
sad	to cheat	plum
pity	to marry	yellow
house	mountain	dear
to die	glass	salt
to quarrel	new	fur
custom	big	to pray
anxious	money	to paint
foolish	part	pamphlet
old	despise	flower
finger	to beat	expensive
box	bird	wild
to fall	family	

For a discussion of the results of this experiment see p. 144.

CHAPTER III.

ATTENTION.

Experiment V A.

The Concentration of Attention.—(*a*) Take some common object like a pen or pencil and try to concentrate your attention upon it for one minute, getting a friend to tell you when the minute is up. The purpose is to discover the number of times your attention wanders from the object in the course of the minute.

Whenever your attention does so wander, indicate it to your partner by the movement of a finger or of a pencil held in the hand. Your partner should count the number of such signs and note it down without telling you, for the present.

Try to hold the object itself in mind, simply the object as it is. Do not think things *about* it. The subject should take special care to indicate the slightest fluctuation of attention away from the object. Of course the attention may wander from the object even when the *vision* is still concentrated upon it.

(*b*) Again, attend to the object for a minute, but this time ask yourself questions about it, *e.g.* as to its size, the proportions of the length to the thickness, the exact shade of the colour, the material of which it is made, the flaws in the making, etc. Indicate as before the number of fluctuations of attention from the object or ideas immediately connected with it. You can now change rôles with your partner.

As always, you should write down as much as you can in the way of introspective remarks immediately after completing the experiment and before turning to read the discussion of the results in Part II

For a discussion of the results of this experiment see p. 147.

Experiment V b.

The Fluctuation of Attention and its Modification by Effort.—The next experiment approaches the same problem as the foregoing experiment in a different way.

Place the figure below in a good light. Stand a card (postcard size is sufficient) upright on the line dividing

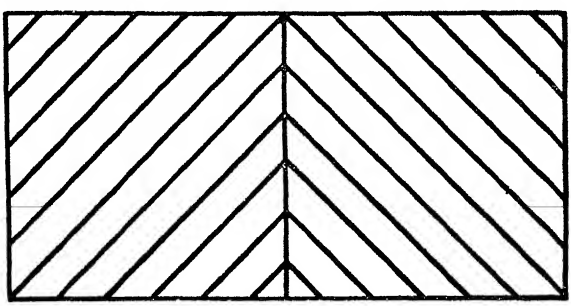


Fig. 1.

the two squares of diagonal lines. Lower the head till the top of the card touches the forehead between the eyes. Try to get the "stereoscopic" effect, one diagram overlapping the other. Note the fluctuation of the lines, first one, then the other predominating. Now try to keep one square clear and in the focus of attention. Note how this is helped by counting the lines, comparing the spaces, etc., on that square.

For a discussion of the results of this experiment see p. 148.

Experiment VI.

The Control of Attention.—The following experiment may be regarded as the converse of Experiment V. A. There we were concerned with keeping something in the mind, here with keeping something out of the mind.

(*a*) Choose a topic of some interest to you; we will suppose it is the holidays just past.

Now for one minute try to avoid thinking of those holidays: if the idea does come into your mind try to put it out as quickly as possible. But do not fix upon any special topic upon which you will think. Let your mind wander freely.

Get your partner to time you; hold a pencil in your hand and whenever you do think of the forbidden topic raise the pencil Your partner must count the number of times you raise the pencil within the minute, and he should note this down without telling you for the present.

(*b*) Now take another minute, and as before try to avoid thinking of the holidays But this time choose another topic which has some interest for you, let us say your future career. Try to concentrate your mind upon this, debating what you shall do, and the how, when, and where of your future movements.

As before, let your partner time you and count the number of times your mind slips back to the holidays, which again you will indicate by the raising of the pencil.

Now compare the number of times the idea of the holidays occurred to you in the first and second experiments.

Subsequently your partner should do the experiment, you timing him meanwhile. It may be well to reverse the order of procedure, having first the minute in which some definite interesting topic is thought of, and second the minute in which the subject merely tries to avoid the forbidden topic.

Strictly we should time the *duration* of the thought of the holidays in the mind, instead of being content with counting the number of times it recurs: for if the idea remains continuously in the mind for a number of seconds in the course of either minute, this will evidently reduce the probable number of times of the recurrence of the idea in that minute.

It would, however, scarcely be possible so to time the duration of the thought, for the very act of indicating that I was now thinking of something other than the holidays would recall the holidays to me. We must therefore be content with a cruder means of measurement.

For a discussion of the results of this experiment see p. 148.

Experiment VII.

The Division of Attention.—Is it possible to carry on two mental operations at once? This can be put to the test thus:—

(*a*) Count aloud the odd numbers, 1, 3, 5, 7, etc., as fast as you can, and see how far you can get in one minute. Note the number down.

(*b*) Now write down in order the letters of the alphabet as fast as you can. When you get to Z begin at A again and go on until a minute is up. Count the number of letters written down.

(*c*) Now try to perform both operations at once, counting the odd numbers aloud and at the same time writing down the letters of the alphabet. Do this for one minute. Compare the number of letters written in this minute with the number written before in test (*b*), and compare the number of figures counted in this minute with those counted in test (*a*).

Note.—As an alternative to the writing of letters the subject may cross out every a, b, and c in a page of print. This avoids the difficulty of keeping the same standard in the writing of letters in both parts of the experiment.

For a discussion of the results of this experiment see p. 149.

Experiment VIII a.

The Attraction of Attention.—(*a*) Read over the following words at the rate of one per second to a friend (or to a class) asking him to remember as many as he can and to write down all he recalls when you have finished the list.

To ensure greater accuracy as regards time it would be well to make use of a watch. The watch should be held to the ear until the four-beat rhythm is clearly apprehended. Still keeping the watch to the ear the words can now be read out as described, each word coming at the first of a group of four beats. Such a group is usually equivalent to about one second in duration.

Read the words quietly with the exception of those printed in capitals, which should be read very loud.

Cage, fan, bench, COUCH, glove, nail, cloud, reel, HEART, camp, brain, foal, POST, desk.

(*b*) Read out the following words similarly at the rate of one per second to a friend (or to a class), asking him as before to write down all he can recall when you have finished. This time read all the words out in a fairly loud tone except those in italics, which should be whispered.

Man, key, sponge, *bat*, cake, book, road, smoke, *fox*, twig, curl, pen, *tub*, wool.

For a discussion of the results of this experiment see p. 152.

Experiment VIII. b

The Distraction of Attention.—(*a*) Take a page of a newspaper (or better a page of the letters provided in Chapter XI.) and, getting a partner to time you, put a dot under every, a, e and o as fast as you can for one minute. This is just for practice. Now begin the test in earnest and continue for another minute. Mark the point reached when one minute is up. After a slight pause,

(*b*) Continue crossing out the same letters for one minute, but during this minute let your partner introduce distractions by tapping loudly on the table every five seconds.

(*c*) After a moment's pause, do another minute's crossing out without any distractions.

(*d*) In the next minute let the distractions take the form of a spoken word every five seconds, e.g. Christmas, Hitler.

The experiment may be varied by doing a task which calls for more thought: e.g. underlining all the nouns in a newspaper column, or doing the multiplication test given in Chapter XI.

In a second experiment the distraction might also be varied every time—bangs, questions, etc. being intermingled.

In scoring, count the number of letters correctly marked in the minute and subtract 2 for every one missed or incorrectly marked.

The disadvantage of using newspaper material is that the letters occur in varying frequency in different passages, and also the reading matter itself is a distracting element of varying strength.

For a discussion of the results of this experiment see page 155.

CHAPTER IV.

ECONOMICAL METHODS OF LEARNING.

Experiment IX.

The Learning of Poetry.—If one has to learn a poem, say of twenty or thirty lines, is it better to learn two or three lines at a time or to read the whole poem through over and over again? Most people unhesitatingly pronounce in favour of the first method. We proceed to put the question to experimental test. Briefly, the method is to spend an equal amount of time in learning two poems of equal length and difficulty, one by the whole and the other by the sectional method, and then to compare our knowledge of one poem with that of the other.

One must first secure two poems or parts of poems of approximately equal difficulty. It is of course not easy to make sure of this; but if a student doubts the equality of difficulty of Pieces A and B on pp. 22 and 23 he can easily perform the experiment on another subject and get him to substitute B for A and vice versa. Or he can repeat the experiment on himself with the other selections at the end of this chapter. Judging from experiments upon the writer's own students the two pieces given seem to be on the average of almost exactly equal degrees of difficulty.

Piece A is to be learned by reading it right through repeatedly. When the subject thinks that he almost knows the piece, he should note exactly how long he has taken, and then he should write out as much as he can remember of the poem.

After a rest the same time should be devoted to Piece B, but Piece B should be learned by sections, the first section, separated from the rest by a vertical line, being repeated until the subject thinks he knows it. Then he should proceed to the second part and learn that thoroughly, and so on until the allotted time is up. Then he should write down as much as possible of the poem.

The amounts learned by the respective methods may now be compared by reckoning the number of words known.

If there is any slackening of effort due to fatigue during the learning of the second piece it should be noted that this is to the disadvantage of the method used second. On the other hand, any improvement due to practice will favour the method used second. These complicating factors can be allowed for by means of a supplementary experiment, in which the order of the methods used is reversed, the sectional method now being taken first. For this experiment the selections given at the end of this chapter may be used.

Alternative Methods.—A method sometimes suggested for doing the experiment is as follows. Piece A is to be learned by the sectional method, the student continuing until he knows the piece perfectly, and noting the time taken or the number of repetitions required. Piece B is then to be learned by the whole method until known perfectly, and the time or number of repetitions noted.

An objection to this method lies in the possibility of wasting more time with one piece than the other by testing oneself to see if one knows it, and it would obviously be awkward to try to measure the time wasted. For this reason I have modified the method as above. But the difficulty may perhaps be avoided if the subject takes care to let each testing be also an occasion for learning. The method has the advantage of securing that the poems shall be completely learned, and this is likely to show more clearly the superiority of the whole method, for the last few minutes tell very heavily with the whole method.

In a *class experiment* the following method may prove more convenient. Let half the class take Piece A and learn it by the sectional method, the other half meanwhile learning Piece B also by the sectional method. Lines are inserted here and there in Piece A to mark the suggested sections for this experiment. Let the class continue learning until one member declares that he knows the piece. Note the exact time allowed. Then let them write out as much of the pieces as they can remember.

After a rest interval of ten minutes the first half of the class should learn Piece B by the entire method, the rest of the class learning Piece A by the entire method, for the same length of time as allowed previously. As before, they must now write out all they can remember, and the total score of all the class by the sectional method should be compared with the total score by the entire method. As each piece has been learned by each method, the possibility of an erroneous conclusion due to the greater difficulty of one piece is avoided.

If time allows, however, each member of the class should follow one of the methods previously described, as the "class experiment" method cuts short the time required by slow learners, to the detriment of the whole method.

PIECE A.[1]

Oh! yet a few short years of useful life,
And all will be complete, thy race be run,
Thy monument of glory will be raised; |
Then, though (too weak to treat the ways of truth)
This age fall back to old idolatry, |
Though men return to servitude as fast
As the tide ebbs, to ignominy and shame,
By nations, sink together, we shall still
Find solace—knowing what we have learnt to know, |
Rich in true happiness if allowed to be
Faithful alike in forwarding a day
Of firmer trust, | joint labourers in the work
(Should Providence such grace to us vouchsafe)
Of their deliverance, surely yet to come. |
Prophets of Nature, we to them will speak
A lasting inspiration, sanctified
By reason, blest by faith: | what we have loved,
Others will love, and we will teach them how; |
Instruct them how the mind of man becomes
A thousand times more beautiful than the earth
On which he dwells, | above this frame of things
(Which, 'mid all revolution in the hopes
And fears of men, doth still remain unchanged) |
In beauty exalted, as it is itself
Of quality and fabric more divine.

[1] The selections are from Wordsworth's *Prelude*. Should either passage be known, or should the student desire shorter or easier pieces, it would be well to use instead the selections from Mrs. Browning's *Aurora Leigh* given at the end of this chapter. Students take, on the average, from twenty minutes to half an hour to learn one of the selections from Wordsworth.

PIECE B.

This spiritual Love acts not nor can exist
Without Imagination, which, in truth,
Is but another name for absolute power |
And clearest insight, amplitude of mind,
And Reason in her most exalted mood. |
This faculty hath been the feeding source
Of our long labour: we have traced the stream
From the blind cavern whence is faintly heard
Its natal murmur: | followed it to light
And open day: accompanied its course
Among the ways of Nature, for a time
Lost sight of it bewildered and engulphed: |
Then given it greeting as it rose once more
In strength, reflecting from its placid breast
The works of man and face of human life, |
And lastly from its progress have we drawn
Faith in life endless, the sustaining thought
Of human Being, Eternity, and God. |
Imagination having been our theme,
So also hath that intellectual Love, |
For they are each in each, and cannot stand
Dividually.—Here must thou be, O Man!
Power to thyself; no Helper hast thou here; |
Here keepest thou in singleness thy state:
No other can divide with thee this work: |

For a combined discussion of the results of this experiment and of Experiment X. see p. 157.

Experiment X.

The Learning of Vocabularies.—The test is to learn the following lists of German words, A and B, by two different methods. Students who know German should use the lists of Spanish words given on pp. 28, 29; or these latter may be used for a supplementary experiment.

Learn List A by repeating the first word and its meaning five times, then proceed to the second word and repeat that and its meaning five times, and so on. Note the time taken by this procedure. If you have a metronome, or a loud ticking clock, it would be well to set it going and move the attention from word to meaning, or vice versa, once every second. When you have thus completed the list, write down the meanings of the words written below the list. In the case of the English words give the corresponding German words.

List A.

Aufmerksamkeit	Attention
Bewegung	Movement
Empfindung	Sensation
Bewusstsein	Consciousness
Gebröckel	Gratings
Reiz	Stimulus
Entwicklung	Development
Gemeinschaft	Community
Anschaulich	Perceptual
Entscheidung	Resolution
Kerbe	Notch
Prahler	Boaster
Hoken	Higgle
Flicken	Patch
Bedrohen	Threaten
Schuppig	Scaly

Test on List A.

Give the English or German for the following words:—

Kerbe	*Reiz*	Patch	*Anschaulich*
Bewusstsein	*Bewegung*	Threaten	Attention
Sensation	*Gemeinschaft*	*Prahler*	Scaly
Resolution	*Entwicklung*	*Gebrockel*	*Höken*

After a short period of rest learn List B by reading the whole list through from beginning to end five times. Try to go at the same pace that you did with List A, if possible using a metronome or clock as before. Note the time taken. It would be better still if you can get a partner to tell you when you have taken as long over List B as you did over List A.

After reading the list through five times write down the meanings of the words given in the Test on List B.

List B.

Auffassung	Perception
Bedingung	Condition
Speicher	Granary
Einschärfung	Injunction
Erinnerung	Memory
Vorstellung	Idea
Zweckmässig	Purposive
Hemmung	Inhibition
Begriff	Concept
Aehnlichkeit	Similarity
Erfahrung	Experience
Kegel	Ninepin
Pflüger	Ploughman
Hutung	Pasture
Fresser	Glutton
Befugt	Authorised

TEST ON LIST B.

Hemmung	*Aehnlichkeit*	Perception	*Begriff*
Bedingung	Experience	*Zweckmassig*	*Einschärfung*
Ploughman	Pasture	*Fresser*	*Befugt*
Idea	Ninepin	*Speicher*	*Erinnerung*

Compare the number of words right in the two tests

If the time taken in List B was not exactly the same as that for List A proportionate allowance must be made for the difference in comparing the scores.

Supplementary Experiment.—It would be well for the private student to do a supplementary experiment with the lists of Spanish words, reversing the previous order of the methods (*i. e.* taking the "whole" method first) and adding the results of the two experiments together. Thus he will counteract the advantage gained by the method used second, in the German test, through any acquired facility at pronouncing the words. In a class experiment this can be allowed for by half the class using the whole method for the first list and the other half using the sectional method.

SPANISH WORDS.

LIST A.

Entregar	Transfer
Alcanzar	Follow
Fuero	Law
Garrama	Robbery
Aldea	Hamlet
Pozuelo	Well
Embaucar	Deceive
Careta	Mask
Farandula	Comedian
Casado	Married

Test on List A.

Give the English or Spanish meanings of the following words: hamlet, *casado*, *farandula*, *alcanzar*, robbery, *fuero*, deceive, mask, *entregar*, well.

List B

Camama	Humbug
Fulano	So and so
Poyata	Cupboard
Cachones	Breakers
Delgado	Thin
Garruchuela	Pulley
Dichoso	Fortunate
Embotar	Blunt
Golondro	Desire
Estambre	Worsted

Test on List B

Give the English or Spanish meanings of the following words: *cachones*, humbug, *poyata*, desire, *delgado*, worsted, *garruchuela*, *dichoso*, so and so, blunt.

Alternative Selections.

Piece A.

He never could be anything complete,
Except a loyal, upright gentleman, |
A liberal landlord, graceful diner-out,
And entertainer more than hospitable,
Whom authors dine with and forget the hock. |
Whatever he believes, and it is much,
But nowise certain, now here and now there,

He still has sympathies beyond his creed
Diverting him from action. | In the House,
No party counts upon him, while for all
His speeches have a noticeable weight.—
Men like his books too (he has written books),
Which, safe to lie beside a bishop's chair,
At times outreach themselves with jets of fire |
At which the foremost of the progressists
May warm audacious hands in passing by.

PIECE B.

I wandered up and down the terraced streets,
The glittering boulevards, the white colonnades,
Of fair fantastic Paris | who wears trees
Like plumes, as if man made them, spire and tower
As if they had grown by nature, | tossing up
Her fountains in the sunshine of the squares,
As if in beauty's game she tossed the dice, |
Or blew the silver down-balls of her dreams
To sow futurity with seeds of thought
And count the passage of her festive hours. |
The city swims in verdure, beautiful
As Venice on the waters, the sea-swan. |
What bosky gardens dropped in close-walled courts
Like plums in ladies' laps who start and laugh: |
What miles of streets that run on after trees,
Still carrying all the necessary shops.

For a discussion of the results of this experiment see p. 157.

CHAPTER V.

MENTAL TYPES REVEALED BY ASSOCIATIONS AND DESCRIPTIONS.

Experiment XI.

Do this and the two following experiments before reading the discussion of them in Part II., Chapter V.

(*a*) Write out a list of words, in the order in which they occur to you, beginning with any word you choose. Do not hesitate to write down whatever comes into your mind, however disconnected it may seem to be from the previous words. When you have completed the list go over it again and add a note to each word, if possible, to make it clear exactly what you had in mind when the word occurred to you.

(*b*) After doing the next experiment (XII.) write out another list of words as above.

(*c*) After doing Experiment XIII. write out a third list of words as above.

It would be better still if these lists could be written on different days and if one or two more could be done, starting with any word the subject chooses.

Experiment XII.

Complete the following partial sentences :—

1. I am now . . . .
2. He saw clearly . . . .
3. In this town . . . .
4. It is raining and . . . .
5. Yesterday we were . . . .
6. Very few men . . .
7. Outside the town . . . .

Experiment XIII.

Place an old penny or halfpenny before you and write a dozen or twenty lines about it.

Do the same with a used stamp, or an old pen-nib.

For a discussion of the results of these experiments see p 162.

CHAPTER VI.

ROTE MEMORY TESTS.

Experiments XIV., XV., and XVI.

The objects of these experiments is to show the distinction between the remembering of (*a*) impressions of sight and (*b*) impressions of sound, and also to find to what extent the student uses visual imagery even in remembering sounds, *e g.* by picturing words which he hears spoken, or, on the other hand, to what extent he uses sound imagery in remembering things seen, *e.g.* by repeating to himself the words which he sees.

The experiments are especially suitable for use with a class; for then individual differences appear, and the independence of different "kinds of memory" is shown. Indeed the use of the term 'memory' or even 'rote memory' will be shown to be inexact. We should rather speak of "remembering visual impressions by rote," etc. The term is used in our chapter title and elsewhere as a convenient abbreviation and the quickest way of indicating to a student what kind of topic is to be dealt with. As we shall see, one of the results of these experiments will be to show that there is no such thing as "*a* faculty of memory."

For the private student a partner is essential. First

perform the following tests upon him, and then get him to do similar tests upon yourself, only substituting different letters, words, etc., for those given below.

Experiment XIVa.

Auditory Memory.—The first test consists in reading aloud to the subject a number of letters; the subject then writes down the letters which he has heard.

For the sake of comparison it is desirable that a regular unit of time should be chosen (say one second), and that a new letter should be read out each second. If the reader possesses a metronome it will be found helpful to set this ticking one per second; the operator then reads out a new letter at each tick. Failing a metronome an ordinary watch can easily be used. Let the operator hold this to his ear until he apprehends clearly the rhythmic tick of the watch. Probably four ticks make about one second. If he taps his foot every fourth tick he will soon get the rhythm quite definitely. Still keeping the watch at his ear, let him now warn the subject to be ready and then read out the set of letters below, calling out a new letter at every fourth tick.

When all the letters have been read out the subject must write down all that he can remember.[1] The subject should be instructed to remember the letters by their *sounds* and to avoid visualising as far as possible.

C N P F S G B W D L Q T

This is primarily a test of auditory memory. The student, however, should note whether he visualised any of the let-

[1] To make the subject duly cautious he should be informed that the writing down of a letter which was not given will score *minus* one.

ters. In so far as this is done the test is not a purely auditory test.

The total score should be noted, no marks being lost because of incorrect order.

A similar further test should now be done, the operator becoming the subject and the previous subject becoming the operator and preparing a new list of twelve letters. Care must be taken, in forming a new list of letters, that no associations are suggested by the grouping of the letters. For example L.S D. or I.L.P. would be bad sequences. Vowels should not be used, as one may chance to form a complete word with two adjoining letters. Any help gained from such associations should be noted.

Experiment XIVb.

Visual Memory.—A similar test for visual memory can now be carried out. As before, warn your subject to be ready and then expose the following group of letters for the same length of time as was taken to read out the twelve letters used in test A.

The subject must be instructed previously to keep his eye upon the centre letter, but at the same time he must try to remember the other letters and also their exact positions in the group.

When the time is up the subject must write down the letters, arranging them exactly as they are arranged in the given group. Letters put in their right places should score two marks; correct letters, but in their wrong places, one mark.

The subject must be instructed to avoid *saying* the letters to himself when looking at them.

R
L V
K M T
X D
J

Now again the subject should become the operator and prepare a similar group to test his partner.

This test is primarily a test of visual memory. But some will find it difficult to avoid saying the letters to themselves when looking at the group. In so far as this is done the test fails to be a purely visual test. But those who have a good visual memory will have a great advantage in remembering the exact arrangement of the letters.

As always in these memory experiments the subject should note whether he derives any assistance from associations, *e.g.* of words with the letters.

Experiment XV. a.

Second Test of Auditory Memory.—Inform your partner that you are going to read out to him nine nonsense syllables of three letters each, specially constructed for this kind of test. Read them out at the same pace as you read the letters, using the metronome or watch as before.

The list should be read three times; then the subject must write out all the syllables he can remember, spelling them as they sounded, and not troubling about position. As always, give your subject the warning "Ready" three or four seconds before you start. The nonsense syllables must be pronounced very distinctly. Score two for each quite right.

MEB PIV RON WOF GAN TOD HIX DIB WAP

As before, the operator should now become the subject, his partner preparing a list of nine nonsense syllables. Great care must be taken to avoid resemblance in a nonsense syllable to any word or part of a word, but it is exceedingly difficult to secure an entire absence of such suggestions in a long list of nonsense syllables. Sometimes a nonsense syllable looks all right but suggests a word as

soon as it is read aloud. Any such suggestions in the course of the experiment should be noted.

Experiment XVb.

Second Visual Memory Test.—Expose the following group of nonsense syllables before your subject, using the watch or metronome as before, and pointing to a new syllable every second. The subject must try not to say the syllables to himself.

After going over the syllables twice thus from top to bottom, the subject must go over them a third time, this time in the opposite direction, from bottom to top. This will make it much more difficult to remember the position of the syllables by the succession of sounds got by pronouncing them silently.

After the third reading the subject must write down the syllables from memory, arranging them in a group as given. One mark is given for every syllable correctly spelled, and an extra mark if it is also in the right position.

SOR
WIB DAK
ZER YIK POS
GEB ZID
VUS

As before, the operator should now become the subject, his partner preparing a new group of nonsense syllables.

Experiment XVIa.

Third Auditory Test.—Read out the following pairs of vowel sounds to the subject. Read out a pair every two seconds, and repeat the whole list three times.

Emphasise the first of the two syllables thus ó–ĭ and let there be a short pause after each pair.

After reading out the list three times, give the test as follows. Read out the first sound of one pair, and ask your subject to write down the pair of which it formed the first.

Here we are testing the power of associating two meaningless sounds together. The subject must try to avoid visualising. This experiment is specially devised to lessen the value of visualisation. For the vowel sounds may mostly be spelt in several different ways and this may lead to confusion if the subject tries to visualise them

The operator should first read over the list to himself and decide exactly how he is going to pronounce each sound. A sample word showing the suggested pronunciation is printed below each vowel or diphthong.

When writing out the answers to the tests the subject should be told to spell them as they sounded to him, giving a sample word with each vowel or diphthong.

1.	Ó . . .	I	5.	OÚ	E
	(go)	(pit)		(thou)	(get)
2.	AẂ	OO	6.	Í . . .	AY
	(law)	(pool)		(pit)	(pay)
3.	EÍ	AY	7.	Ó	OU
	(my)	(pay)		(pot)	(thou)
4.	AH́	EE	8.	EÉ	OO
	(ah)	(feel)		(feel)	(pool)

In testing do not follow the order given above. Score two for each pair correct.

A rearrangement of similar vowel sounds will now serve as material for the testing of the previous operator.[1]

[1] If comparison of results of the partners is desired a third person should act as operator in this experiment; otherwise the partner is likely to fix certain associations in reading out the pairs which he will have to *unlearn*.

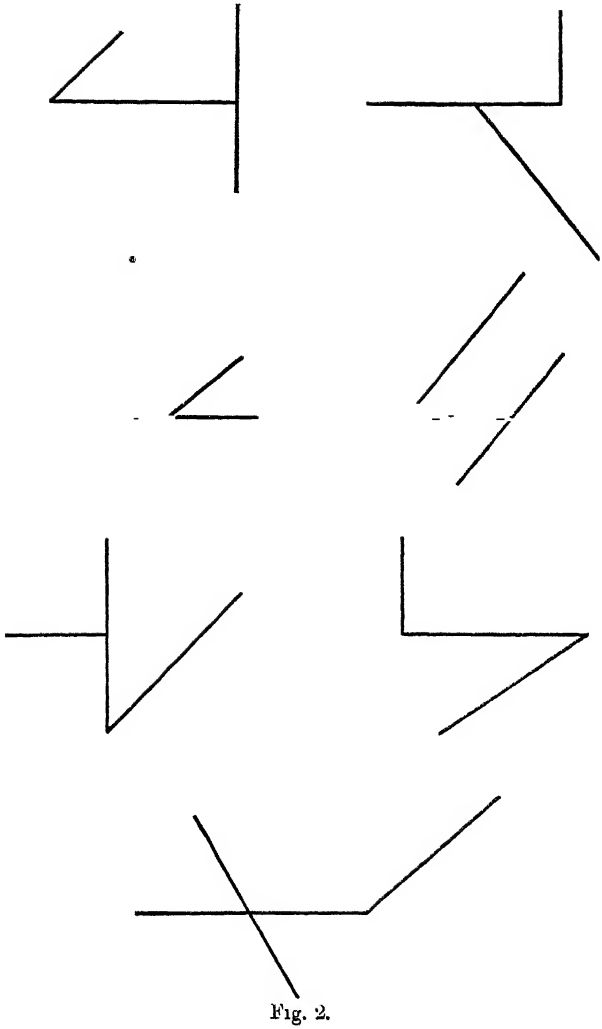


Fig. 2.

Experiment XVI b

Third Visual Test.—The third visual memory test is almost a purely visual test, with meaningless diagrams.

Expose the seven diagrams given below, giving time for the subject to go over all the figures three times.

The operator should use a stop watch as before and point to a new figure every three seconds.

The subject should be informed that the figures consist of three lines, mostly just one inch long, but some only half an inch. Also that all the angles are either 90°, 45°, or the supplement of 45°.

After the exposure the subject must reproduce as many figures as possible. A figure reproduced with complete accuracy scores two marks. One mark is allowed for a figure with the wrong length for one line. If the subject unintentionally gets associations with any of the figures he should note the fact.

The student should now write down any observations he has made as to his own method of learning and memorising, and especially as to whether he finds much greater facility in remembering visual or auditory impressions. Of course we cannot compare the total of the three visual tests with the total of the three auditory tests, as we have no ground for saying that it is equally easy for the average person to score as well in one set as in the other.[1] But the student may find interesting differences between himself and his partner, the one being superior in auditory and the other in visual memory.

If the experiment is done in class an order of merit, based on all three tests in visual memory, should be drawn

[1] Also, the maximum for the visual tests is slightly greater than for the auditory. The writer has sometimes modified the tests he uses in class in order to suit better the private student. Thus he cannot give the usual results.

up, and then an order in auditory memory. The student will then know his comparative proficiency in each type, and any considerable difference in order will be instructive

It should be noted that all these tests have been tests of "*Immediate*" memory, *i.e.* of impressions received only a few moments before recall. The student may also try how much of the given material he can recall a day or a week after the tests. If a number do this it will probably be found that those who are best in immediate memory tests are not necessarily best in prolonged memory tests.

For a discussion of the results of Experiments XIV., XV., and XVI. see p. 173.

CHAPTER VII.

ON THE VALUE OF A MAP.

Experiment XVII.

For this experiment the private student needs the assistance of a friend who will act as experimenter while he is the subject. Below are given two pieces of imaginary "history." Piece A is to be read out by the experimenter to the subject (or to a class).

Piece A is illustrated by a map, to which the operator must point at the appropriate times while this piece is being read out. The exact time taken by the lesson should be noted by the experimenter.

The piece should be read only once, then the subject (or class) should write down the answers to the questions given below, which should be read out by the experimenter.

Subsequently Piece B should be read out, at as nearly the same rate as possible to that of Piece A. If it is found that it is finished in less time than was taken to read Piece A (as is not unlikely owing to the use of the map with Piece A) a portion can be re-read until the time is completed. Now Questions B must be answered.

Historical Piece A.

In the first year of the reign of William X., of Zamboo, A.D. 2100, a revolt occurred among his subjects living among the hills of Ranah. In these almost inaccessible heights the king's civilised troops at first could do little to suppress the revolt

Eventually, however, the greatest leader of the day, General Denmer, took command of the army, and set out with a large force northwards from Kali on the River Tam. This river flows near the base of the highest hills in the Ranah range, and its valley formed an excellent route for the march.

At Sulby, quite by the hills, they were surprised to find a large band of the rebels holding the pass up to the mountain villages. General Denmer, however, leaving a force of 500 men to hold the enemy in check at Sulby, secretly accomplished a forced march towards the south-west and round the hills, and thus captured Otonga, the principal village of the rebels

[The names of the King and the General are also printed on the map. This is to be regarded as equivalent to their being written on the board in a school lesson.]

Questions on Piece A.

1. In whose reign did the rebellion take place?
2. In what district did the rebellion take place?
3. What was the date?
4. In what country did the king reign?
5. Who took the lead of the expedition?
6. From what town did they start?
7. Where exactly was the town situated?
8. In which direction did he start?

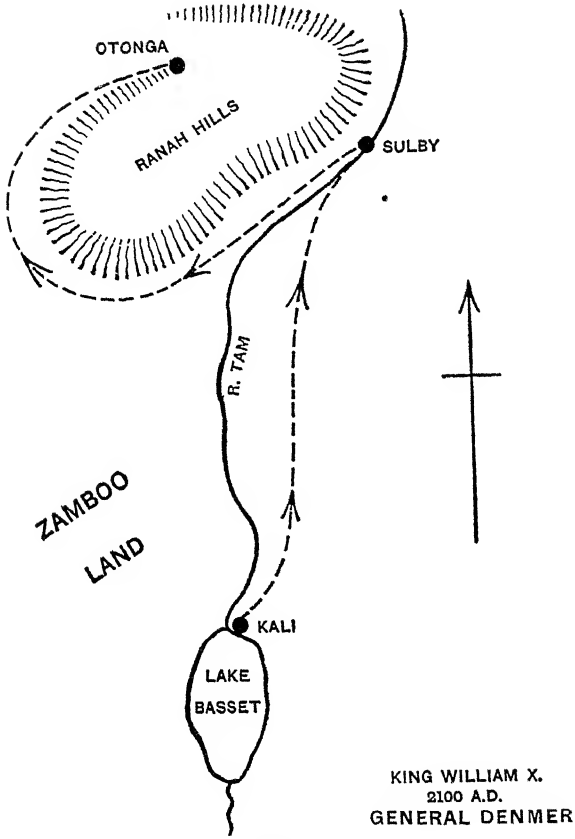

OTONGA
RANAH HILLS
SULBY
R. TAM
ZAMBOO
LAND
KALI
LAKE
BASSET
KING WILLIAM X.
2100 A.D.
GENERAL DENMER

Fig. 3.

9. How was the route determined?
10. Where did they find the first rebels?
11. How many men did they leave there?
12. In which direction did the general now march?
13. What was the name of the place captured?

Historical Piece B

The discovery of Feddah Land was the occasion of many interesting adventures. Captain Betler, who was in command of the ship, approached the land from the east, following the strong currents which set in that direction Starting in the reign of Peter VI., A.D. 1560, from Kenda Town on the Island of Fanly, they sailed for some days in dangerous seas, and eventually reached the mainland of Feddah with some difficulty. The place at first seemed almost uninhabitable, little being discovered in the way of food. Eventually the party of discovery established their base at a spot they named Erman, situated between two huge promontories. Hence they started into the interior, taking with them rations for thirty days which they had brought from the ship. They had not gone many days directly inland when Captain Betler found that a sharp turn towards the north was necessary, to avoid the huge volcano (called by them Aurora, after the ship). Nestling under the lee of this mighty mountain they discovered a charming glen where they made their second depôt, named Densar.

Questions on Piece B.

1. What was the name of the land?
2. Who was the captain?
3. From what direction did they approach the land?

4. How was this direction determined?
5. What was the name of the king?
6. What was the date of the discovery?
7. From what town did they start?
8. Where was this town situated?
9. What was their first base?
10. Where was it situated?
11. For how long had they rations?
12. In what direction had they to turn after going inland?
13. What was the name of the second depôt?

See p. 178 for a discussion of the results of this experiment.

CHAPTER VIII.

SUBSTANCE, RATIONAL OR LOGICAL MEMORY.

Experiment XVIII.

Read out to your partner (or to yourself) the first list of words below, and ask him to write them down at once. Then read out the second list and ask him to write down these also.

As before make use of your watch or metronome, giving one second to each word.

1. Strict, cot, pan, gate, friend, table, paper, bird, flower, bite, walk, piano, ship, glass, photo, bucket.

2. Christmas, plum-pudding, mistletoe, parties, dancing, games, children, snowball, ice, skating, hole, danger, ducking, cold, bed, doctor.

Note the ease with which the words connected in meaning are recalled and the comparative difficulty of recalling the disconnected words, in spite of the fact that these are considerably shorter. Your partner should now be asked to make similar lists and read them out to you.

Experiment XIX a.

For this experiment you need, for the sake of comparison, at least one fellow-subject, who has also been a subject in the rote memory tests.

Get your partner to read over with you the three following passages, the first two of which are taken from a

daily newspaper. After all three have been read, close the book, and attempt both of you to reproduce all that you can remember, not seeking to reproduce the exact words, but making sure at least of as many ideas as possible. This experiment is of special interest if done by a group of persons who have already done the rote memory tests. The point of the experiment lies in the comparison of the results with those of the rote memory tests: one fellow-subject may prove quite inadequate for the purpose of comparison.

(i) *Flooding the Sahara and its effects.*

The project of flooding the Sahara desert and converting it into a great inland sea has again been mooted, this time by a distinguished French engineer, but the scheme, as it always does, has thrown the scientific world into a paroxysm of fear. The hot sands of the Sahara, though they are so many hundred thousand miles of waste, play the part of what has been called the stove of Europe. Let in the flood of cooling waters, and, according to a distinguished professor, the climate of France and Germany will become sub-Arctic, while England will be almost uninhabitable.

(ii) *Causes of the present labour troubles.*

In the consideration of the present labour troubles there is a tendency to overlook the important part which the natural desire of mankind to be better off plays in provoking discontent. A recent writer thinks that existing social conditions are not the sole cause of the unrest through which we are now passing.

It arises in very many instances from the higher conceptions of life which have been formed by the workers. Education has awakened aspirations which, in the present circumstances, it is impossible to realise. Men and women

are asking for better wages and working conditions simply because they desire to live better, cleaner and healthier lives, the benefits of which they have been taught to appreciate.

(iii) *The Influence of the Press.*

As the influence of the hearth depends from day to day upon the way in which the parents naturally accentuate some things in word and deed and let others pass away unnoted amongst their ever-watchful children: so is the influence of the daily press upon the national mind. They might fill their pages from day to day with the records of crime, and feed their readers on the refuse of the police courts. They might ignore good causes and great ideas of reform, advocating none of them and expounding none of them when they are weak, but leaving them to gather force as best they may. Instead of guiding they might follow the interests of men, and, in following, not always follow the best of them. And if they did this, day by day, I do not think it would be easy to measure the consequences on the national character. But, taking the daily press of this country as a whole, it seems to me that they do much better. They deliberately exclude what they know their subscribers would read; there are appetites which they will not feed and tastes which they will not pamper.—From *Social Powers*, by Sir Henry Jones

The marking of the reproductions of these passages is difficult. A mark should be awarded for all the broad facts given, even if they are differently expressed and even if minor points are omitted or are inaccurate. Below is given a suggested analysis and system of marking for passage (i). The subject can agree with his partner for similar marking for the remaining pieces.

One mark for the idea that	}	the flooding of the Sahara will convert it into *an inland sea or lake.*
,,	,,	it has been suggested by *an engineer.*
,,	,,	it has been suggested *again,* or any words that imply that the suggestion had been made before.
,,	,,	the suggestion has *caused fear.*
,,	,,	the fear has been caused *in the scientific world* (because it is the scientific world that can understand the consequences).
,,	,,	this is *what always happens.*
,,	,,	the Sahara *acts as a stove.*
,,	,,	it warms *Europe.*
,,	,,	the Sahara *appears to be waste land.*
,,	,,	the *waters will have a cooling effect.*
,,	,,	they will make *France and Germany* (or N.W. Europe) *sub-Arctic* (or excessively cold).
,,	,,	they will make *England almost uninhabitable.*

The other pieces should now be marked in a similar manner

Experiment XIX. b.

Intermediate and Prolonged Memory.—The foregoing passages may be used to test the difference between an individual's 'immediate' and 'prolonged' memory of logical material, as compared with that of other persons. The class may be asked, without previous warning, to reproduce any of the above passages a week or two after they had been read. Similar tests may also be given with any of the "rote-memory" material. It will be found that

those best in the 'immediate memory' tests are not always best in 'prolonged memory' tests.

See p. 180 for a discussion of the results of these experiments.

Experiment XX.

Variations in Repeated Reproductions.—Paragraphs (i) or (iii) of the preceding experiment, or better, either piece given for the next experiment (Expt. XXI) may be used in this experiment. The paragraph should be read carefully once (or read aloud to the class). After an interval of half an hour or longer, during which the subject should read something else (or the class listen to a lecture) the subject should then write out all he can remember, label it Reproduction No 1, and put it away. After an interval of a day (or better several days) without looking at his first reproduction, he should write out again what he remembers. (The class could do it at a weekly or bi-weekly lecture). This should be repeated about half a dozen times Then all the reproductions should be compared.

For a discussion of the results of Experiment XX see p. 183.

Experiment XXI.

Group Serial Reproduction.—For this experiment a group of persons is needed. A large class should be divided into rows or groups (labelled A, B, and C, etc.) not exceeding about 8 each if the experiment is to be concluded within the hour. This experiment also can be done while a lecture is going on without much interruption of the lecture.

Procedure. (A) **Written Reproductions.**—A copy of the following story is given to No. 1 of each group who reads it and turns it over. After about 3 minutes the lecturer says "No. 1 of each group write the story out and hand your report to No. 2." After again giving

an interval of about 3 minutes, the lecturer says, "No. 2 of each group write the story out and hand on report to No. 3," and so on During the intervals the students attend to the lecture. This in itself is a useful addition to the experiment.

At the end of the experiment the last student in each group reads out his record, and the original story is re-read.

(B) **Oral Reproductions.**—If preferred the story can be read only by No 1, and then repeated by word of mouth, No. 1 whispering in the ear of No. 2 and so on, like the old parlour game. It it important here that enunciation should be clear: a student should be permitted to ask for the repetition of a word if it is not clear to him.

At the end of the experiment the last member of each row repeats what he remembers and then the original story is re-read.

(C) **Alternative Procedure for Written Reproductions.**—For a large class a convenient procedure is the following, which avoids the duplication of copies of the story. The lecturer reads aloud the story at the beginning of his lecture. After about 3 minutes he gives a signal for student No. 1 to write it down, and show his record to No. 2. After another 3 minutes a signal is given for No. 2 to write what he remembers and show it to No. 3, and so on. Students are allowed to use their recollections of both the lecturer's reading and their neighbour's written account.

Spies in London.

I saw in the *Daily Reporter* that an ugly man who looked like a foreigner, possibly Belgian or German, had been found in a small London hotel near Euston, with photographs of naval docks and gun emplacements. A beautiful

but swarthy-complexioned woman with him had in her bag a newspaper cutting with a faded photograph, possibly her own, from a foreign newspaper, which showed that she, (the woman in the photograph) had been the wife of an Italian officer, and that her husband had been shot as a spy during the Great War. Only last week two Germans were arrested as suspected spies. They were found in offices which were said to belong to the Fascist party, but these reports emanate from Conservative circles and Fascists declare that they are Communist offices.

For a discussion of the results of Experiment XXI. see p. 183.

CHAPTER IX.

METHOD OF FINDING THE CORRELATION BETWEEN TWO ORDERS.

We have already found it interesting and useful to compare two orders of merit, *e.g.* in logical and rote memory, but we have so far been content with a rough comparison, or with the statement that it is possible to be high in one list and low in another, *i.e.* to be very good as regards one kind of memory, compared with other people, but weak in the other.

We often similarly compare the orders of a school class in, say, arithmetic and recitation, and we say, perhaps, that we find that a boy may be good in one subject and poor in another; or we may compare the orders in mathematics and science, and say that most boys who are good in mathematics are likely to be able to do science well.

Now it would obviously be useful if we could make more definite statements of this kind. For example, it would be useful to know to what extent the order of merit in rote memory is likely to resemble the order of merit in logical memory, and whether there is usually more resemblance between the orders for mathematics and science or between the orders for mathematics and Latin. This degree of resemblance between two orders is called their "degree of correlation." We shall see directly how useful it proves if we can discover simple mental tests which correlate highly with general intelligence, or at least which give about the same order of merit when applied to a school class as

would be given by the teacher in a careful estimate of the general intelligence of his pupils after long acquaintance with them. We are enabled to give such definite estimates of correlation by the method now to be described.[1]

Suppose we want to discover whether there is greater connection between the performances in mathematics and science or between the performances in mathematics and Latin. At a first glance this may be difficult to decide, especially if the lists are long ones. For the sake of simplicity we will here use quite short lists of ten pupils.

The first thing to be done is to arrange the pupils in order of merit in the first pair of subjects, thus :—

	Mathematics.	Latin.	Gains.	Losses.
A	1	1		
B	2	4		2
C	3	3		
D	4	2	2	
E	5	8		3
F	6	7		1
G	7	6	1	
H	8	9		1
I	9	5	4	
J	10	10		
		Totals	7	7

Subtract each boy's order in Latin from his order in mathematics. Where the number for Latin is lower than that for mathematics the subtraction will give a plus quantity, and this should be reckoned as a *gain*. Where the number for Latin is greater than that for mathematics

[1] The method described is Spearman's "Foot-rule of Correlations." See *British Journal of Psychology*, Vol. II., p. 89.

we shall have a minus quantity, and this is reckoned as a loss. The total gains and losses are shown above. These should always balance one another.

Obviously the more alike the two orders are the smaller the gains (and losses) will be. By use of a simple formula it is now possible to calculate the extent to which the orders are alike. The figure which indicates this is called the "coefficient of correlation" and is represented by R.

Where two orders are exactly alike the coefficient of correlation, R = 1. This is called "complete correlation."

If R works out as approximately 0 it means that there is no correlation, *i.e.* that there is no greater connection between the orders than may be expected merely on the basis of chance.

If the coefficient works out to a minus quantity it means that there is a tendency for the pupils who are high in one order to be low in the other and vice versa, and this is called "inverse correlation."

The formula referred to is as follows:—

$$R = 1 - \frac{6 \times (\text{the sum of the gains})}{n^2 - 1},$$

when n = the number of pupils in the class.[1]

In the order given above this works out as follows:—

$$R = 1 - \frac{6 \times 7}{10^2 - 1} = 1 - \frac{42}{99} = \frac{19}{33},$$

$$i.e.\ R = 0{\cdot}57.$$

This would indicate a moderately high degree of correlation between mathematics and Latin. In other words, we could say that, as far as one can judge from these orders, there is a distinct tendency for a boy who is good in mathematics to be good in Latin also. We have now to compare

[1] The sum of the gains may be represented by Σg, so that the formula runs $R = 1 - 6\,\Sigma g/(n^2 - 1)$.

this result with the correlation between mathematics and science.

Supposing that we have the following order in mathematics and science :—

	Maths.	Science.
A	1	2
B	2	1
C	3	4
D	4	3
E	5	5
F	6	7
G	7	6
H	8	8
I	9	10
J	10	9

Here it will be found that the gains total 4 and R is approximately 0·76, a higher coefficient of correlation than was found between the orders for mathematics and Latin. This would mean that there is a greater resemblance between the order for mathematics and science than there was between the orders for mathematics and Latin.

We have taken a small number of pupils for the sake of simplicity. Correlations between orders less than about thirty are in fact very unreliable—the element of chance is so great.

Further, it must be clearly understood that for any wide generalisation as to such correlation between mathematics and science or mathematics and Latin we must not only have far more pupils but also a considerable number of tests to eliminate variable accidents.[1] Furthermore, we must do the tests in many different schools before we can state broadly that there is more connection between

[1] See also paragraph on Probable Error below.

proficiency in mathematics and science than there is between mathematics and Latin. We can, however, state that in this particular class as taught and examined by this particular teacher such and such is the case.

Naturally we cannot ignore the question of the influence of the teacher. The order in science, for example, when taken by teacher A may vary considerably from the order when taken by teacher B. Indeed two different examinations by the same teacher may give orders varying appreciably one from another

The Use of Correlation with Memory Tests.—If the memory tests have been done in an experimental class orders of merit should be drawn up for the "rote" and the "logical" tests, and the student should now find the degree of correlation between the respective orders. He will probably be surprised at the low coefficient of correlation if the class has carried out the experiment thoroughly, *i.e.* if the rote tests have really been rote tests, from which associations have been entirely or almost entirely excluded, and if the substance or logical tests have been marked in such a way as not to favour unduly the person who learns easily by rote. The present writer in his experimental classes has had correlations as low as 0·2, and even lower, between the orders for rote and logical tests. The correlation may also be found between the visual tests and the auditory tests.

A More Exact Method of Calculating the Correlation of Two Orders.

The above 'foot-rule' is, admittedly, only a rough and ready method of calculating correlations, giving coefficients somewhat too small. It is not satisfactory for research purposes. A more exact method is the following, taking,

as our example, the same order as above for Mathematics and Latin.

	Maths. Order.	Latin Order.	Difference (d).	Square of the Difference (d^2).
A	1	1	0	0
B	2	4	2	4
C	3	3	0	0
D	4	2	2	4
E	5	8	3	9
F	6	7	1	1
G	7	6	1	1
H	8	9	1	1
I	9	5	4	16
J	10	10	0	0
				36

In the new formula, the coefficient of correlation is indicated by the Greek letter ρ (Rho), the number of persons by 'n,' and the formula is

$$\rho = 1 - \frac{6 \times \text{sum of } d^2}{n\,(n^2 - 1)}$$

$$= 1 - \frac{6 \times 36}{10(10^2-1)} = 1 - \frac{216}{990}$$

$$= 1 - 0\,22 \text{ (approximately)}$$

$$= 0{\cdot}78.$$

This is appreciably larger than that given by the 'foot-rule.'

Roughly, the values of R between 0·1 — 0·45 should be increased by about one-half to give the more exact figure, values between 0·45 and 0·65 should be increased by about one-third, and values between 0·65 and 0·5 by about a quarter.[1]

For further discussion of the uses of such 'correlations' see page 186.

[1] See the table given by Spearman in his article on the Foot-rule, p. 104.

CHAPTER X.

THE SUPPOSED "IMPROVEMENT OF THE MEMORY" AND THE TRANSFER OF IMPROVEMENT

Experiment XXII.

Purpose of the Experiment.—Is there such a thing as a general "faculty of memory" which can be improved by practice? Supposing that by practising the learning of poetry I can memorize poetry better, does this also "improve my memory" for prose, or for dates, or for mathematical formulae, or lists of foreign words? These are the questions which we now proceed to consider. It is possible for a single student (or a pair of students) to perform the experiment and to gain some insight into the relevant facts and into the method of experiment. But for statistical results of any value we need the co-operation of a large class. We will describe the experiment first as a class experiment and then indicate what may be done by the student working alone.

It is a lengthy experiment and not many classes or students may be able to find time for it, but it is included as a good introduction to the fundamental problem of "transference of training," even if the student only reads this chapter and the corresponding one in Part II. Further, he will be familiarised with an important method of experiment in psychology, which has already been used also in the study of some educational problems.

The Method of Equal Groups.—The principle and method of the experiment are broadly as follows. We will suppose that the class numbers thirty. The whole class first undergoes the memory Tests A in syllables, letters, and verse, and their scores are noted. The class is now divided into three groups of ten each

It is important that at the start the groups should be fairly equal, on the average, in their capacity to do such tests as A and B A list should therefore be drawn up of the order of merit on the basis of the results of Test A. The first student on the list should be put in Group I., the second in Group II, the third in Group III., the fourth in Group III., the fifth in Group II, and so on, thus—

Group I	Group II.	Group III.
1	2	3
6	5	4
7	8	9
12	11	10

Thus each group will have its fair share of subjects good or weak in remembering such material as is given in the tests.

During the following fortnight (or month) Group I. learn poetry by heart for half-an-hour a day; Group II. learn vocabularies of any foreign language for half-an-hour a day; while Group III., called the "control" group, do nothing specially for the experiment, only avoiding as far as possible any learning of verse or vocabulary during that time. At the end of the fortnight the whole class undergoes the memory Tests B in letters, nonsense syllables, and verse, which have been made as much like Tests A in degree of difficulty as possible.

By a comparison of the results of Test B with those of Test A it will now appear what improvement has taken

place in the capacity to memorise the various kinds of material.

The control group serves three purposes. (1) It is a check upon the comparative difficulty of the two tests A and B. If one is much more difficult than the other it will appear in the different records of the control group's scores in the respective tests.

(2) It indicates the extent of any possible improvement of memorising due to natural growth, or to the ordinary learning work done during the fortnight.

(3) Thirdly, and perhaps most important, it indicates the effect of practice gained merely in the doing of Test A itself. This of itself will aid subjects somewhat when they come to Test B, more especially as regards the test with unfamiliar nonsense syllables.

Thus if the control group shows a certain improvement in Test B upon Test A we must allow for this in considering how much of the improvement of Groups I. and II. is due to their special practice with poetry or vocabularies in the course of the last fortnight. Thus an improvement in the second poetry test of 20 per cent. on the part of Group I. cannot be attributed to their fortnight's practice in learning poetry if the control group also shows an improvement of 20 per cent. in the second poetry test.

Both Tests A and B should be done at about the same time of the day and when the subjects are feeling quite fresh, so as to avoid any variations due to fatigue.

In the class experiments the teacher will of course check the time, unless the students are working in pairs.

In this class experiment the students may either work in pairs as indicated, or the lecturer may expose the letters and nonsense syllables for the prescribed period and read out the poetry (say 10 times) and the auditory rote-memory tests.

Method for Individual Students.—If a pair of students are working at the experiment one may act as a "control," as above, taking Test A with his partner before the practice period and test B also at the same time as his partner afterwards. This will form a partial, though of course inadequate check, not only upon the equal difficulty of Tests A and B,[1] but also on the amount of improvement in Test B which is likely to result merely from the practice gained in Test A itself. This is not likely to be much in the case of the poetry, but with the letters and nonsense syllables it may be considerable.

Owing to the possible variations due to individual peculiarities, variations in fatigue, etc., even very marked improvements in the tests on the part of the practised partner can only doubtfully be ascribed to the practice during the week in poetry and vocabularies.

Experiments of this nature require a large number of subjects before we can generalise with confidence. Yet the private student may well learn the principle involved in the method of the experiment and also he may learn much from self-observation in the course of the experiment. He should notice carefully any method or device he adopts in the course of the practice period, any way in which he modifies his way of learning so as to make it more efficient, and especially any way in which practice with one kind of material seems to help in learning another kind of material. The student should get his partner to time him while doing the tests.

[1] Of course it does not avoid the possible errors due to one test being for some reason harder for one subject, and the other test being the harder for another subject. By taking groups of subjects, however, one greatly lessens the chances of such errors.

In a class experiment it would be well for half of each group to do Test A first and Test B later, the other half taking Test B first and Test A later.

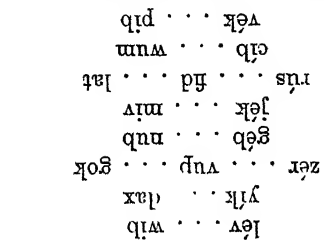
TEST A.[1]

(1) **Learning Letters.**—Look at the following group of letters for ten seconds, keeping your eye on the centre letter, but trying to remember all. Then write down the letters in exactly the same arrangement. Reckon one mark for every letter right, and two if it is in its correct place Do not turn over until your partner is ready to time you.

LETTERS FOR TEST I.

F
B L
Z R G
T M
J

(2) **Learning Nonsense Syllables.**—Learn the following groups of nonsense syllables, with the rhythmic emphasis as marked, emphasising the first syllable of the pair or trio. Repeat the groups thus for two minutes, trying to remember the syllables in pairs (or trios), so that when you are given one of each pair (or trio) you can complete the pairs (or trios). The syllables are turned upside down to prevent you from reading them easily before the moment you are ready to start. Do the test below immediately after learning the nonsense syllables.



[1] As before, note whether any associations or suggestions of meaning occur. These must be allowed for in comparing results.

Write down the syllable or syllables which were grouped with the following syllables. (N.B. It is not necessarily the *first* syllable of the pair which is given here.)

zer, jek, dax, rus, lev, vek, wum, geb

(3) **Learning Poetry.**—Learn the following lines of poetry. For the sake of uniformity use the same method throughout these tests, whatever method you are accustomed to. Note exactly how long you take to learn the lines perfectly.

Hast thou not mark'd, when o'er thy startled head
Sudden and deep the thunder-peal has roll'd,
How, when its echoes fell, a silence dead
Sunk on the wood, the meadow, and the wold?
The rye-grass shakes not on the sod-built fold,
The rustling aspen's leaves are mute and still,
The wall-flower waves not on the ruined hold,
Till, murmuring distant first, then near and shrill,
The savage whirlwind wakes, and sweeps the groaning hill.

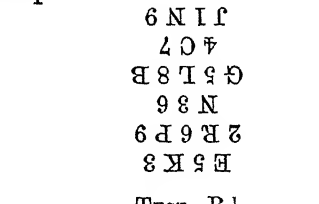
(4) **Auditory Memory Test.**—Get your partner to read out to you the groups of letters and figures written below.[1] They are to be read out in a monotonous tone, no emphasis being given to the first or to any letter or figure of the group.

One letter or figure should be read every second, except that at the end of each group there should be a pause of three seconds. A watch should be used as described in Experiment VIIIA., p. 20.

The whole series should be read out three times and then the subject should write down all that he can remember,

[1] As your partner will thus have already seen this test, you must prepare a test of a similar nature for him if he is to do the experiment subsequently.

in groups as given. One mark should be allowed for each letter or figure in its right group. No marks are to be lost for the wrong position of any letter or figure, if it is in its proper group.



TEST. B.[1]

As before, get a friend to time you in all these tests which follow:

(1) **Learning Letters.**—Look at the group of letters at the bottom of page 68 for ten seconds, keeping your eye upon the centre letter, but trying to remember all. Then write down the letters in exactly the same arrangement as that given. Reckon one mark for every letter right, and two if it is in its correct place.

(2) **Learning Nonsense Syllables.**—Learn the groups of nonsense syllables which are given on the next page, with the rhythmic emphasis as marked, emphasising the first syllable of each pair or trio. Repeat the groups thus for two minutes, trying to remember the syllables in pairs (or trios), so that when you are given one of each pair (or trio) you can complete the pairs (or trios). The syllables are turned upside down to prevent you from reading them easily before the moment you are ready to start. Do the test below immediately after learning the nonsense syllables.

[1] As before, note whether any associations affect the results of the rote memory tests.

rúx . . . ʃáv
yóʧ . . . vár . . . gix
sév . . . pib
wúf . . . nud
bér . . . ʃal
dóv . . . neg . . . bur
méf . . . som
vím . . . bud

Write down the syllable or syllables which were grouped with the following syllables. (N.B. It is not necessarily the first syllable of the pair that is given here.)

mef, ber, dov, vim, pib, rux, nud, yot

(3) **Learning Poetry.**—Learn the following lines of poetry, using the same method as before. Note exactly how long you take to learn the lines perfectly.

Stranger! if e'er thine ardent step hath traced
The northern realms of ancient Caledon,
Where the proud Queen of Wilderness hath placed
By lake and cataract her lonely throne;
Sublime but sad delight thy soul hath known,
Gazing on pathless glen and mountain high,
Listing where from the cliffs the torrents thrown
Mingle their echoes with the eagle's cry,
And with the sounding lake, and with the moaning sky.

(4) **Auditory Memory Tests.**—Get your partner to read out to you, in a monotonous tone, the groups of figures and letters written below, no emphasis being laid on any letter or figure of the group.

One letter or figure should be read every second, except that at the end of each group there should be a pause of three seconds. (A watch should be used as described in Experiment VIII A., p. 20.)

The whole series should be read over three times and then the subject should write down all that he can remember, in groups as given. One mark should be allowed for each letter or figure in its right group. No marks are to be lost for the wrong position of any letter or figure if it is in its proper group.

The scores of all the tests in Test B, should now be compared with those of Test A; and the student before reading the discussion of this experiment in Part II, Chap. X. of this book, should try to account, from introspection, for any marked differences between the scores of corresponding tests.

For a discussion of the results of this experiment see p. 192.

LETTERS FOR TEST I.

H
N C
D P K
F S
W

CHAPTER XI.

THE ACQUIREMENT OF SKILL. MOTOR HABITS AND MOTOR MEMORY. THE METHOD OF TRIAL AND ERROR.

Experiment XXII.

Method of Experiment.—For this experiment a small mirror and some squared paper are required. The squares should be small, preferably not less than ten divisions to the inch.

Trace on the paper six figures similar to the one given in Fig. 4. This can easily be done by placing the given figure over a portion of the squared paper, pricking through to the paper at the points of the various angles, and then joining these points on the squared paper with pencilled lines.

Stand the mirror upright on the table about a foot in front of you, and place the first traced copy of the irregular figure on the table between you and the foot of the mirror. Arrange the paper so that you can easily see the reflection of your pattern in the mirror.

The task is to trace over the pattern as rapidly as possible with a pencil, while looking only into the mirror. A screen should be introduced between the eyes of the subject and the pattern itself. A piece of paper held by the subject in the left hand will suffice.

Start with your pencil on the point marked A and move it over the pattern in the direction indicated by the arrow,

until you come back to A again. Note the exact number of seconds it takes to complete the round Try to trace the lines as accurately as possible and at the same time try to go as fast as possible. Note any introspective observations after you have completed the figure; *e.g.*, do you

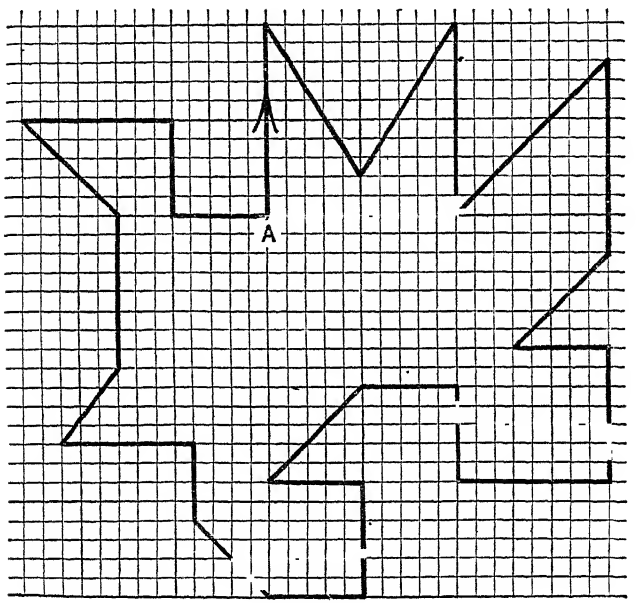


Fig. 4.

make use of reflection as to which way you should move the pencil or do you just "go at it slap-dash"? How is your progress affected by pleasure at success or annoyance at failure? Does your improvement seem to be constant, or is it irregular? (Errors in later figures will show this.)

Now proceed at once with the second figure, again noting the time taken, and so on till the twelve figures are completed

If the reader subsequently tries to trace the figure directly, *i.e.* without the use of a mirror, he will probably find an amusing disturbance of the normal coordinations of eye and hand.

Treatment of Results.—The student should plot a curve showing the various times taken for the different figures.

The accuracy of the work now remains to be calculated. One error should be counted every time the pencil moves one square away from the line. If it moves two squares away, this counts two errors. Or if it moves only one square away but continues so for two squares, this counts as two errors. Similarly an error should be counted for each individual square in which it continues to be one square away from the line. The total errors in each figure should thus be estimated and a curve of errors plotted.[1]

For a discussion of the results of this experiment see p. 197.

Experiment XXIV.

Motor Memory Tests.—As supplementary to the preceding experiment two brief motor tests are described in this and the following experiment.

[1] The method of this experiment is a modified form of that of W. F. Dearborn and D. Starch. The plan of estimating errors simply by reckoning the number of attempts to move back to the pattern line seems to me unsatisfactory.

For another method of experiment with mirror-drawing see C. Burt, "Experimental Tests of General Intelligence," *Brit. Jour. of Psych.*, Vol. III.

In the learning of all movements with the hand, complicated or simple, we are guided, party at least, by a series of motor sensations due to the position of the fingers, hand, and arm, among which the most important are the sensations derived from the joints. When a movement is thoroughly learned it is because a given complex of motor sensations (apprehended in relation to the end in view) suggests the next appropriate movement, and the new complex of sensations—and "end-in-view"—suggest the next movement and so on.

Similar processes are involved in all such actions as writing, drawing, woodwork, etc., though of course the eye also plays a highly important part in such work. The desirability of training directly the motor sensations themselves in teaching children to write has recently been especially emphasised by Mme Montessori, who makes the little beginners move their fingers over large letters made of sandpaper. In this way movement is guided by touch, and not merely by sight.

Some tests of such motor sensitivity and of the ease or difficulty with which the necessary associations are made and previous motor sensations recalled are afforded by Experiments XXIV. and XXV.

Memory of Direction of Movement.—Get your partner to hold a long pencil firmly in his hand in a vertical position, and to close his eyes. Do not let him see Figure 4 on the next page.

You must now also take hold of the pencil near the top, and practise guiding his hand. The subject's arm must be raised from the table so that the hand can be moved easily by the operator.

The operator should now trace the lines of the figure below with the pencil, the subject still holding it, so that he will feel the movements though he will not see them.

Then move the point of the pencil till it is over a clean sheet of paper, and let the subject try to repeat exactly the same movements and so draw a similar figure.

The subject must as far as possible avoid counting the movements or visualising the figure when his hand is being guided over it; he must endeavour to concentrate his attention on the sensations due to the moving fingers, hand, and arm. Some subjects, however, may find it impossible to avoid all visualising.

MOTOR MEMORY TEST.

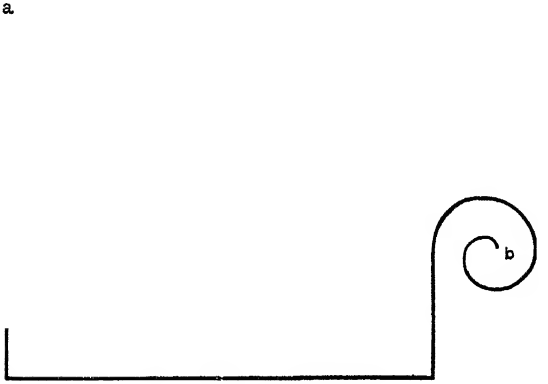


Fig. 5.

If the figure is not done correctly the first time, the subject's hand should be led over it again and again until the figure is done correctly, the number of repetitions necessary being noted.

Several figures (not too small) of equal or greater complexity can easily be devised by the operator. As before, the operator and the subject should now change places.

Experiment XXV.

Memory of Extent of Movement.—Fasten a tape measure to the edge of a table with drawing-pins. Seat the subject opposite one end, with the tape measure stretching away to his right; he should be near enough to the table to reach two or two-and-a-half feet along the measure with his right hand, without moving his body.

Let him close his eyes, extend his right hand, and rest the first finger on the near end of the tape measure.

The operator should now slide the subject's finger along the tape measure for some distance, say 24 inches, and then slide it back to the end. The hand should be moved at a constant speed, and not so far as to cause any movement of the body.

The subject must now try to slide his finger, without guidance, to exactly the same spot as before.

The operator should note the exact amount of error. Five similar tests with various distances should be done, and the average amount of error noted.

As a variety of this experiment test the memory of "active" movement. Let the subject move his finger along the tape to any distance he desires, with eyes closed; then let him slide his finger back to the end of the tape. Now let him try to move the hand exactly as far as before. Compare the accuracy in this test with that of the test above.

There is no separate discussion of the results of Experiments XXIV. and XXV. They are to be regarded as supplementary to Experiment XXIII., which is discussed in Part II., Chapter X., p. 197 and to the Tests of Motor capacity in Chapter XXII

CHAPTER XII.

MENTAL WORK AND FATIGUE.

Experiments XXVI. and XXVII

Purpose of the Experiment.—The object of these experiments is to indicate the manner of the onset of fatigue in the continued performance of mental work, and to show the various conflicting influences, *e.g.* practice, "warming up," boredom, fatigue, which are present at one time or another in the course of prolonged mental work.

The tests which follow may be used also to detect the presence of fatigue at different parts of the day, or to compare the amount of fatigue after working at, say, mathematics with the amount of fatigue after working at history, or after an hour's gymnastics (see Experiment XXVII.).

Method of Experiment XXVI.—For such purposes we evidently require a test in which work of a very constant degree of difficulty can be given and which can be accurately and exactly marked. As samples of such tests two are given below, viz. multiplication, and cancellation of letters.

The student should select one of these and it would be well if he could do an hour's, or at least half-an-hour's continuous work at the selected test. Individuals vary greatly, and some may find they get interesting results with less work than this. But the student should go as far as

possible beyond the stage at which he *thinks* he is fatigued. There is no necessity for him to select an hour when he is vigorous and fit for other work. Indeed it is preferable that he should select a period when fatigue is likely to show itself.

He must endeavour to work at full pressure throughout the test. He should secure himself as far as possible from all likelihood of noises or other interruption during the period of work.

If possible he should be timed by a friend who should indicate to him by some signal the end of every two minutes, when the subject should make a mark showing how far he had progressed in his work by that time.

If the student is working alone he should do half a page in Test A (or one column in Test B) and note the length of time taken. Then he should proceed at once to the next half-page (or column), timing that, and so on. This method, it should be noticed, introduces a complicating factor not present when the subject is timed by another, —namely, he is aware of the fact that he is improving his pace or otherwise.

Finally, as always, the student is urged to write down at the end of each test any introspective remarks, *e.g.* as to his own feelings of fatigue, the apparent causes of delay at certain points, any change or improvement of method due to practice, and his own impressions as to his comparative speed at different times, the signs of the onset of fatigue, the approach of boredom, the effect of a special effort to press the speed, etc.

Alternative Method for Experiment XXVI.—An interesting variation of either test may be made by introducing a rest of five or ten minutes after the first half-hour's work, and noting the effects, both subjective and

objective, of this interval. The student is recommended to adopt this modified plan. If a class of students is doing the experiment it would be well to divide it into three groups, giving one group no pause in the middle of the work, a second group two minutes' pause and the third group ten minutes' pause.

Of the two following tests the reader is strongly advised to select the second, Test B. The method of the experiment, it is true, is not so simple, but for this very reason it will prove more interesting. Also correction of the results will take less time for Test B than for Test A, and there is less likelihood of muscular and eye fatigue.

For Test B enough material is given for an hour's work. Sample pages of letters suitable for Test A are also given, sufficient to give those readers who select Test B for their "fatigue" experiment some idea also of the nature of the work involved in Test A. Each of these sample pages contains all the letters of the alphabet, each repeated twenty-six times, but in haphazard order. Those who choose Test A for their "fatigue" experiment must select some ordinary printed matter, continuous prose, printed alike throughout, and this should be used throughout the experiment.

Test A.

Cancellation of Letters.

The task in this test is to cross out as quickly as possible every example of several selected letters, in the printed capitals on pages 79 to 81. For example, the subject may decide to cross out every A and every F. The more letters are chosen, of course, the greater the mental effort. Four is a fairly convenient number, say A, F, M, and L.

As all the letters of the alphabet occur an equal number of times within every page, it does not matter much which letters are chosen for deletion.[1]

When ordinary printed prose is used for this test of course it makes a considerable difference which letter is chosen, as some occur so much more frequently than others. The most uncommon letters should then be avoided.

The subject must take care to put his pencil mark right through the letter. A partner should indicate the end of every two minutes, and a mark should be made showing the point reached at that time; if this plan is not adopted the subject must time himself for every half-page. When the beginning of the last period of two minutes is reached the subject should be warned of this fact.

When the period of work is completed the letters crossed out during each period of two minutes should be counted and a graph should be plotted showing the various amounts done in the successive periods. Every occasion on which the subject has omitted to cross out one of the selected letters counts as an error, likewise any letter crossed out which was not one of the selected letters, unless the mistake was apparently a "motor" error (see below). A separate graph should be plotted for errors.

Motor Errors.—Sometimes the student may have evidently intended to cross out one of the selected letters but may not have put his pencil mark properly through the letter. These letters should be included in the score of crossed out letters, but a separate note of them should be made as "motor" errors.

[1] Except that some letters stand out especially clear in a page of printed capitals. For example the student should not select O or Q for cancellation.

WKBROGDJSKWGYARJUIVEUXCETC
OZEJKMDHYUPSYUIVFHJHMDBWSM
PMQTGYLALXRXHPGFCFNQIERCVF
ATOZVNZPNWBLXAZSKQBTIDOLNQ
DMKCIWZHTNEVWOVKYLOHTSPZDA
FLVUMNQSXHRZMFSWIXOKUQPMKO
JLNSVWEIJCXWTYLUORWGDXUJLW
MJNKQETHZIQFXBGHUFRAHGTRUK
TNGIFBRVURGKNBMXPCVDQSVYGP
CPAVFSDGCIBTZASJCQAOYPIACY
BQMEOHWBDJCPTLYZQKLPNBLESU
AHZNAJEGDBZFRXOFJYIEMDRYEX
XWRTOXTZFBKALZIVQMYIPNETXS
EVIFZHWMCEKLZJQBEOIHYUEZVA
BDUAXLVCQFCDIHUSWNZPJOKNAB
JMWNXGCQHTCVDTNJOUWNXICSJA
SMTBGDUFPCBYZFWOIQJMCHUKRP
UNDMRYBTALYBFRMVGDLGFIHUAV
KYDGZSEGWAEOSKSNMLPWSKHQRJ
ORXLPEVDRGLHTFJYOPYQXPQRKG
MVUNLIMGBTJNZJBZYWGESYANKW
HYIXMZTHQMZTWKGLCHVIRPWQYB
APHGRPDWQJTHWPRZUOCLQNXODP
CKDVKMVCOGRELODASKUDARFXCA
IZVQFGELXBQPTRMUFJYIOHYUAN
JEXSFDTCSKBUEXVDOLFSIBNJFS

UKAURMBXFTAKOINWKVDWNBNOUI
IWMDJVMYJKTEYWNENSNHDFRQOV
XLHJKSFJROWFBDSAQVOLFSYNBW
SYURDGWXQHVYSWUGQSYHFGTPNT
MWXMSKEVIOEXFLRUIMWCDAKSRA
WJFECLPECYKLDQMEPDQSJMGKAW
QCNEFCNAXNQGMGYELPDVTXVUOH
HWUFWBNADSFJMLQIFDEVMQJBTM
EYXVMIGKYMYZOWJCRBFPXDHTRK
AKELGNQUCBHTJHIBRTGAVKHPEK
LFMZKGDCMEKFTHQOTKCYXBRWOU
KAZMQJBUWZKSIWUCLZFLMYXWGV
ZLXWJVTVYXAUZGOSFXRVHWBLXU
VCXHZNRLDGFZPMLCWYNTGUSQUX
HJWIPMQKHVOIXRHZVIDBXTDTZX
CWECKTIPIFLBQKAOJOLBNXZVCE
UHJXRBFTZXJDNUZMFUJDYUCVPF
UIJRAVDSIZQJGRZNPAIZTQDNGA
PSBGIYNLRISBZISEYZAGJDOZOI
QISNFYQSJHFPOFEPNTNOIQTICA
EZOHRHLGTPZQTPXEZOGMLYAZOP
APAQPCGBCWAJDCMRTOLRAOLECO
GCLQKZJWYRHRDBFRABVPHGCBPX
RLCBMBEJFASDYRLTNSPCSQVGKO
UESDURPZEGTPKUHNUXMVIQDYPU
YGBPIJHMNVBVYKYJTAEHSCHLSO

YRFVYSUTNWILQOMYOGHDEKOYRX
WVLYOCTMAKVOFDHQMIBQUZLXJP
SOKAVUAUMSDACGQESDWUXQFVTK
YKHUQHWTZHYPNCJWHZRKICMHAC
JTXFSZKOEFWYHTQMAEYKVAOJWL
PXRGDGQBHGKVTEUIENUXNAWKID
ZYKTEVUTRNWECFJHVZMNKAPMVO
WJMDVLRFYSQFQAPUMRQSWJWKFE
MXZGJYEJMGDZMSMBDVJAQNMGEV
YJZLICNPSLDZDQTYUYZOFDRZIU
JMXMQWVZMAFKRCAMKRPKNSXPQI
CHTHGHUGUXCBXHFCGKENUVAOHS
NTXJBSXYJYUGCDOQLVRZPSRJQS
ZFXNXVZAYUXZVDCFYAJCGMWXOA
FPLXSIMDTQKZBLIYKGKXIDWKDX
TPWVDFNJCGBPFRBJDCIJRXRNRO
OXPTJWDCIQMLDCLSRJBXOPFSPT
UFBFGWVUAPJBPTBDHSWXAGUBTI
WUARBGZHOHCXTHPBQMDIFRZLGR
NYBDEIHETYLJNECSBOFPKVBCGO
AEBLVNAUTEAOJGNRWRPNSRVHPW
NYEOEBVLWSLZSNEBNFUBPEHZAN
CZEILEIBSJBPTIQICIEOYNCNZC
EUHLCWXWGFIHTHDSQFVAYLGRAU
OWKIIOKOITGSSPGIVYRPELQIDL
QBMULPLZGZRQHKLFOTNTKMLQBM

Experiment XXIV. Test B.

Multiplication.

Columns are given on succeeding pages for multiplication. The method to be pursued may appear somewhat complicated at first, but with a little practice the student will rapidly become accustomed to it. Briefly the method consists in multiplying four successive figures, but paying attention only to unit figures.

Suppose we have the column

6
4
9
2
7
8

The first figure is to be multiplied by the second, viz. $6 \times 4 = 24$. The unit figure of the result, 4, is now multiplied by the third figure of the column, 9, thus $4 \times 9 = 36$. The unit figure of this result is now multiplied by the fourth figure, viz. $6 \times 2 = 12$. The unit figure of this is now written down beside the 2. Now the student goes back and starts with the second figure of the column, viz. 4, and multiplies it by the third, viz. $4 \times 9 = 36$. As before the unit figure of this result is multiplied by the next figure, thus, $6 \times 2 = 12$, and the unit figure of this is multiplied by the succeeding figure 7, thus, $2 \times 7 = 14$. The unit figure 4 is now written down beside the 7. Now go back again and start with the third figure 9 and multiply it by the underlying figure 2 and proceed as before, writing down the unit of the third result beside the figure 8.

The column will now appear thus,

6
4
9
2..2
7..4
8..8

The subject should proceed in this manner till he reaches the bottom of a column and then he should start afresh with a second column.

One special case must be mentioned. Where the figure which has to be multiplied happens to be 0, 1 must be substituted for it. Thus in the following column

4
5
7
6..2

proceeding as before, $5 \times 4 = 20$. Substituting 1 for 0 and proceeding as before we get $7 \times 1 = 7$, then $7 \times 6 = 42$, the 2 being written down as above Of course if the 0 appears as the unit figure which has to be written down, it is not changed to 1, but the 0 is written down, as it has not to be further multiplied. It would be well if the student would make a short column and give himself a preliminary practice before starting the experiment proper.

Naturally it is possible to use a much simpler method. For example, we might multiply the first figure by the second and write down the whole result at once, and then multiply the second by the third and write down the whole result and so on, thus

5
8...40
2...16
7. .14

Two important differences, however, would be introduced. In the first place much less mental effort is involved, as the figures are all before one's eyes and there is not the complicating element of retaining one figure only and dropping the other. Secondly, there is much more writing down in proportion to the amount of mental work done, and muscular fatigue of the hand may precede mental fatigue.

A partner should indicate the end of every two minutes to the subject, who must make a mark showing how far he has progressed by that time. When the beginning of the last period is reached the partner should warn the subject of this fact, saying "Last two minutes" Failing a partner, the subject should time himself for each column.

On subsequent pages the requisite columns of figures are given. They will probably be found adequate for an hour's work. On the succeeding pages these columns are reprinted with the correct answers in their right places.

This arrangement will make possible the rapid correction of the lists, especially if a partner reads out the correct answers.

After correction the student should plot curves indicating the amount of work done in the successive periods of two minutes, and a second curve indicating the number of errors in each period. If the student has been working alone and timing each individual column he can plot the curve in seconds showing the time taken for the successive columns.

The student may avoid the writing of figures between the printed columns by using a strip of paper for each column. This will enable him to use the printed columns again on a subsequent occasion, or for another subject. It will also greatly facilitate correction. The strips of paper should be prepared and numbered before the experiment is begun

For a discussion of the results of Experiment XXVI. see p. 202.

8	6	8	6	5	6	9	7	8	8
3	3	9	9	1	5	3	8	5	4
5	4	4	2	6	9	8	4	2	3
7	7	5	3	8	8	7	9	6	9
9	2	7	8	3	3	5	4	1	5
4	5	9	5	9	1	3	2	8	7
8	8	3	7	4	7	9	9	4	2
2	1	1	9	7	4	4	8	3	4
6	9	7	5	2	8	7	3	7	1
1	7	2	1	5	6	8	6	5	8
8	9	4	3	8	5	7	7	9	9
9	8	9	6	6	3	9	2	2	3
4	2	8	9	5	3	5	4	5	6
7	6	5	8	4	1	2	7	6	7
6	3	9	9	2	8	3	5	8	2
3	5	6	5	3	5	1	9	3	9
2	8	5	1	6	7	4	8	5	4
5	3	7	7	9	4	7	3	7	8
9	2	4	6	2	1	5	2	5	6
7	9	8	8	5	4	8	6	9	5
3	6	9	9	7	9	6	9	3	2
9	4	2	4	3	6	9	8	8	4
8	5	5	5	8	8	5	4	9	3
5	7	3	7	5	3	8	5	3	6
6	1	2	9	6	4	4	3	5	7
4	9	9	2	1	9	7	8	7	8
7	7	6	3	8	6	5	9	4	9
3	5	5	8	5	7	6	5	2	5
6	2	4	5	7	2	2	4	6	3
9	8	7	2	6	5	5	9	5	5
5	6	8	3	3	8	1	3	4	4
6	7	9	6	2	3	3	2	8	7
5	5	3	9	9	6	8	6	9	6
8	8	8	7	8	2	6	1	6	9

3	2	8	3	9	8	9	8	6	7
8	4	6	4	7	6	7	7	9	8
9	8	3	7	5	1	8	6	4	6
8	6	4	8	3	5	3	2	3	9
1	5	9	6	8	3	2	9	6	3
5	3	5	3	6	8	4	8	8	1
2	9	8	4	2	5	2	3	3	5
4	8	7	7	9	6	6	5	4	7
7	4	2	9	4	2	8	7	9	8
9	1	3	3	3	7	1	1	2	4
2	6	1	5	5	4	3	4	6	2
1	8	8	2	7	3	2	7	7	6
3	3	9	8	5	9	7	5	5	7
6	2	5	1	9	8	9	3	6	9
8	4	6	5	8	6	7	2	9	6
7	8	7	4	1	2	6	9	5	3
2	3	3	3	7	9	2	8	7	5
5	9	6	6	4	7	5	9	6	4
9	7	8	7	2	9	8	6	3	2
3	6	7	9	6	6	7	8	8	3
8	2	6	2	5	1	4	1	9	7
7	9	9	1	8	3	3	4	2	8
6	4	4	8	6	5	2	5	5	9
2	5	9	3	9	8	5	2	4	7
4	7	8	6	4	7	9	9	5	6
9	8	6	1	2	9	8	7	8	5
3	3	7	8	7	2	7	1	9	4
5	4	2	7	5	4	6	3	6	8
7	9	5	9	3	8	1	8	3	3
3	6	3	3	9	6	8	7	4	2
8	2	9	8	7	7	3	9	7	4
4	4	3	5	1	9	5	3	9	2
9	9	6	3	6	3	3	2	8	6
6	6	8	1	3	2	5	6	5	8

5	3	2	3	5	9	1	4	1	9
7	1	4	9	1	6	7	3	3	6
2	7	7	2	3	1	6	6	9	8
9	6	9	7	6	3	4	8	2	3
6	8	5	4	7	9	2	1	7	5
7	6	7	7	4	7	9	4	6	4
8	8	6	9	9	4	5	2	5	7
3	9	3	3	2	3	7	3	8	2
2	3	8	6	6	8	8	2	7	9
4	1	6	2	8	9	7	9	9	5
6	7	1	5	1	6	4	8	4	3
8	2	4	8	3	5	2	7	3	8
1	6	2	4	4	4	9	9	1	4
5	9	3	2	7	3	8	7	6	9
7	5	9	6	5	8	3	8	5	3
9	2	6	9	8	5	9	6	2	5
2	4	5	3	3	4	6	8	9	2
5	3	8	5	6	9	5	3	2	7
8	8	7	2	9	7	2	2	5	8
9	6	2	8	6	6	8	5	8	5
3	9	4	7	3	2	3	3	4	6
2	5	3	4	4	7	9	4	3	9
7	8	8	8	7	8	5	6	8	7
6	2	9	5	2	3	6	1	6	8
1	5	7	9	6	5	7	9	7	1
4	7	8	6	8	2	4	6	8	3
3	9	5	3	5	7	2	5	9	9
6	3	7	1	4	8	6	4	6	7
8	7	6	9	7	3	7	3	7	2
3	2	3	6	1	6	4	6	5	4
6	1	2	7	9	5	3	1	3	5
9	8	6	5	5	4	5	4	4	3
4	6	8	3	8	9	7	2	8	9
7	8	9	2	4	4	9	9	9	8

8	6	8	6	5	6	9	7	8	8
3	3	9	9	1	5	3	8	5	4
5	4	4	2	6	9	8	4	2	3
77	74	50	34	88	82	72	96	62	94
95	28	77	82	34	33	50	42	16	50
40	50	93	50	96	16	33	28	86	75
86	88	35	77	44	78	95	98	42	20
26	18	19	93	76	44	40	86	36	44
64	99	79	55	24	84	76	32	72	16
16	74	22	15	50	64	86	66	50	84
86	97	46	35	88	50	78	78	95	98
92	86	94	60	68	33	98	22	20	36
48	28	86	92	50	39	50	46	55	66
76	64	50	86	44	15	20	72	66	74
62	38	99	98	28	82	33	50	88	22
34	50	64	50	36	50	13	99	34	96
22	88	55	11	64	77	44	80	50	44
50	33	77	75	94	48	74	33	77	86
99	26	48	60	24	11	50	22	55	68
73	92	88	86	50	42	88	68	95	50
35	64	96	94	77	94	66	94	35	22
91	42	26	48	31	66	94	84	80	48
82	50	50	50	80	88	50	48	94	32
50	77	33	77	50	36	88	50	38	64
66	17	26	93	66	46	44	33	50	74
44	95	99	20	16	94	78	84	75	88
78	71	64	38	88	68	50	99	40	94
34	55	50	82	50	72	66	50	22	50
64	20	44	50	77	26	22	44	66	33
94	88	78	22	62	50	50	99	50	55
50	68	86	36	33	88	11	37	44	40
66	72	96	68	22	34	33	26	82	77
55	50	32	94	94	68	80	64	92	62
80	88	88	74	82	28	64	16	68	92

3	2	8	3	9	8	9	8	6	7
8	4	6	4	7	6	7	7	9	8
9	8	3	7	5	1	8	6	4	6
88	64	46	82	35	50	32	22	38	94
16	50	98	64	80	33	26	96	68	36
50	33	50	38	66	80	42	84	86	12
22	97	88	46	28	55	28	32	32	55
44	80	77	74	94	66	66	50	46	75
78	44	24	96	42	22	84	77	94	80
94	18	36	36	36	74	16	15	26	44
24	62	12	55	50	46	34	40	62	28
16	82	88	20	77	38	28	76	76	64
34	34	96	88	55	96	72	50	50	76
66	28	50	18	95	84	98	33	66	96
84	42	66	50	80	66	72	20	99	68
78	82	77	44	11	24	66	99	55	34
22	32	31	33	74	94	26	82	77	50
50	94	66	68	44	76	50	96	60	44
99	72	88	74	26	94	88	68	33	22
37	64	78	94	66	62	76	86	88	36
80	26	66	26	50	18	48	12	96	78
72	96	94	16	88	32	32	42	22	86
68	42	42	84	68	50	28	50	50	92
22	50	94	38	94	80	50	22	44	78
46	77	82	64	48	77	99	98	50	64
92	86	68	14	22	93	82	73	80	50
36	33	74	84	74	28	77	16	92	44
50	42	22	76	50	44	64	39	64	82
75	94	50	94	33	86	16	88	36	34
35	68	33	32	95	64	86	78	48	22
80	22	97	82	75	74	34	92	74	42
42	42	35	50	19	94	50	32	96	28
94	92	66	33	68	34	33	28	86	66
68	62	86	13	36	28	55	64	50	84

5	3	2	3	5	9	1	4	1	9
7	1	4	9	1	6	7	3	3	6
2	7	7	2	3	1	6	6	9	8
99	66	94	78	60	32	48	86	24	36
66	86	50	44	76	92	26	14	78	50
76	66	75	72	44	79	92	42	66	44
84	84	60	94	92	46	50	24	50	77
38	96	33	36	24	36	77	34	88	24
26	36	88	64	62	82	80	28	76	94
42	16	64	24	84	94	77	98	93	50
64	79	14	50	16	66	48	82	46	33
84	22	42	88	34	50	28	78	36	80
12	64	28	42	46	44	94	96	18	44
50	96	34	28	74	32	86	78	62	94
77	50	96	64	50	84	32	88	50	34
95	22	64	92	88	50	94	64	22	50
20	44	50	34	33	44	66	88	98	20
50	32	88	50	68	96	50	32	28	77
88	82	76	20	96	73	22	28	50	86
92	66	24	88	62	62	86	50	88	50
37	96	48	76	32	26	34	33	42	66
22	50	38	48	48	78	92	42	32	94
78	88	82	82	74	82	50	66	88	73
62	22	94	50	28	36	60	12	66	84
14	50	72	99	66	50	77	96	78	14
48	77	82	64	82	22	48	64	88	38
32	93	50	33	50	77	26	50	94	96
62	35	77	12	44	86	66	44	64	79
86	73	62	92	78	36	76	32	74	28
32	28	33	62	17	68	46	68	50	44
64	12	22	78	92	50	34	12	33	50
96	82	66	50	55	44	50	42	40	33
48	66	88	33	80	96	77	28	88	97
72	84	94	20	44	46	95	92	94	80

Experiment XXVII.

Comparative Estimation of Fatigue at Different Periods or after Different Kinds of Work.—Either Test A or Test B of Experiment XXVI. may also be used to compare the amount of work done at different times of the day or after various kinds of other work. Thus the student may do a page of calculations or two pages of letter cancellation in the early morning, and again in the afternoon and late at night, timing himself on each occasion. Or he may on one day do the test after a morning at hard study, and on the next day he may do a similar test after a morning spent in vigorous physical exercise. As already hinted, he must be alive to the likelihood of improvement due to practice, especially in the more difficult work of calculation. For example, one subject made the following scores in quarter-hour tests at the various times mentioned:—

Tuesday	2.30 p.m.	(feeling	fatigued)	108	answers right.
„	7.30 p.m	(„	fresh)	152	„ „
Wednesday	11 a.m.	(„	fresh)	179	„ „
„	2.30 p.m.	(„	fatigued)	161	„ „

The improvement in the score for the second test cannot be ascribed merely to the subject's being more alert mentally. Practice certainly is partly responsible for the improvement, and probably even for the further improvement shown in the third test. In the fourth test, even if there is still some improvement due to practice, the fatigue invariably felt by this subject at this time of the day showed itself by the first drop in the score.

As a partial check upon the effect due to practice the student can arrange the tests as follows. Suppose he wishes to see whether a morning at study or a morning's

strenuous physical exercise fatigues him more for arithmetical calculations. He should do half-an-hour's work at Test B after the morning's study; on another day he should do the test after the physical exercise; on two subsequent days the order should be reversed, the first test coming after a morning's exercise and the second after a morning's study. Thus the effect of practice will favour the test after study in the first pair of tests, and the test after exercise in the second pair. We cannot, however, assume that the effect of practice will be the same in both cases. It will probably be greater in the second test than in the fourth. But the results may be such that some inference is possible in spite of the complicating effects of practice. Thus suppose the figures are as follows:—

1st.	Day	Test I.	After study	100
2nd.	,,	,, II.	After physical exercise	130
3rd.	,,	,, III	After physical exercise	135
4th.	,,	,, IV	After study	165

Such a record may probably be interpreted as follows. Score IV. improves on score III. much more than score III. does on score II. Now it is very unlikely that practice effects will show themselves more in the fourth period than in the third. We may therefore suppose that the superior score of test IV. is due to the fact that the subject is less fatigued for arithmetical work after a morning's study than after a morning's severe physical exercise. That score II. is greater than score I. in spite of this may be ascribed to the great improvement in the test work due to practice at this early stage.

For reliable results, however, the above series should be repeated, this time in the following order: Test I., after physical exercises; test II., after study; test III., after study; test IV., after physical exercises. Or the

student may with some tests practise the method repeatedly when feeling quite fresh and at about the same time of the day, until no further improvement is apparent and the scores maintain a fairly constant level. Naturally, the easier the test the more rapidly will such a stage be reached. Some recent experiments indicate that, with the multiplication test given, improvement may continue to take place, with regular practice, for many weeks; and the highest degree of efficiency in these experiments was only reached after having some practice periods of about ten hours each, which seemed to have a great effect in improving work on subsequent days.[1]

In so far as the student wishes to know how far the variations in the amount of work are due simply to his varying mental condition according to the time of the day, he should as far as possible let the periods preceding the tests be spent pretty much alike. It would obviously be unsatisfactory to do a test at 12 midday after a strenuous morning's work, then another at 4 p.m. after an easy afternoon, and then to suppose, if the scores are equal, that he is normally as mentally fit at 4 in the afternoon as at midday.

For a further discussion of the results of Experiment XXVII. see p. 209.

[1] See "Some Effects of Prolonged, Unvaried Mental Work," by F. M. Ritchie, *Forum of Education*, Vol. II., Nos. 1 and 2.

CHAPTER XIII.

THE TRANSFERENCE OF EFFECTS OF TRAINING.

Experiment XXVIII.

The cancellation of letters test and other experiments in this book can also be used for an experiment on the transference of training effects, the important psychological problem at the basis of the "Formal Training" dispute. The following procedure for a class experiment can be modified for an individual working alone, in a similar way to that suggested for Experiment XXII. (The Transfer of Memory Improvement).

(*a*) The class, working in pairs, will cross out the letters E, N, H, T, M on p. 79, each student being timed by his partner. After the student has done his first page, his partner will do a page, being timed as before. On the basis of the scores the class will be divided into two "equal groups" (p. 61). One group will practise crossing out at full speed adjectives and verbs in any pages of printed prose for twenty minutes (*or* for twelve periods of five minutes each during the next few days). A second page of letters must now be dealt with as above by both groups. Errors and time in first and last tests must now be reckoned. In the "practice" work it is important that the material used should be homogeneous: then in the long practice period the partners can indicate to the subjects three or five minute intervals, and thus the rate of improvement in the practice work can be calculated and compared with the improvement of Test II. on Test I., percentages being reckoned.

(*b*) The experiment may be done in another form, the first and last tests this time being to cross out prepositions and adverbs in printed prose, the practice work being to cross out verbs and adjectives. It is essential that the prose matter of Tests I. and II. should be homogeneous.

In either experiment (*a* or *b*), if the first method (continuous practice at one sitting) is followed, there should be an interval of ten minutes between the practice and the final test, to reduce the chance of either fatigue or "warming up" influencing the work of the second test. While one group is practising, the other group may be preparing apparatus for Experiment XXIX

Experiment XXIX.

(*a*) By one partner lines of sizes from 3 to 9 inches in length are ruled on pieces of paper, the lines increasing in length by $\frac{1}{2}$ inch. The pieces of paper should be of equal size and shape, or should at least increase regularly with the length of the lines. It is very important that no distinguishing feature should be present other than the length of line. In this and the second series of lines the length of each line should be written on the back of the paper. Another set of lines are made from $\frac{1}{2}$ to 2 inches in length, increasing by $\frac{1}{8}$ inch.

Taking the long series first, the second partner is shown three specimens (5, 6, and 7 inches), and told their lengths, and that, in the whole series, sizes vary by half-inches. He is then tested in judging the lengths of this long series, the papers being presented in haphazard order, and no information being given as to the accuracy of each guess. The series should be presented twice, a record being kept of each answer for each size. The subject now practices judging the sizes of the smaller lines, himself noting the size after each guess, until marked and stable improvement takes place. A record

of each estimate should be kept At the start he should observe carefully three samples, $\frac{3}{4}$, $1\frac{1}{8}$, and $1\frac{5}{8}$ inches. A second test is now given with the first set of lines (again the three samples being shown first), and the percentage of improvement on the first test is compared with the percentage of improvement shown in the practice work, as indicated by the average of the last two presentations compared with the first. The most accurate method is to compare the average of the *amounts* of the errors in the two tests.

In a class experiment the class may be divided into "equal groups" on the basis of Test I., and only one group practised with the smaller lines. (This will indicate how far improvement in the second test is due to the practice gained merely by doing the first test.) In this case the first series must be so arranged that no student learns the actual size of any lines after judging it. One or more sets of lines must be prepared for the class, each line being labelled with a letter, A, B, C, etc., in haphazard order. The lines are passed round the class; each student takes one line at a time and writes down his estimate of its length, indicating which line by the letters A, B, etc. The experimenter afterwards reads out the correct answers for each letter, after the lines have been removed from sight. (Only one presentation of the series is given in this class experiment.) It is better if the experimenter himself corrects all papers.

The practice with the short lines is now done by one group as above, Test I. being then repeated with both groups.

(*b*) The experimenter cuts out a dozen pieces of paper in rectangular form, varying in size from 160 to 400 sq. cm., and marked A, B, etc., in haphazard order. A second set of ten is to be cut, of sizes 10 to 110 sq. cms., but of varying shapes other than rectangles (triangles, pentagons, etc.), and marked L, M, N, etc., in haphazard order.

A third set of ten rectangular pieces should also be cut out of sizes from about 10 to 110 sq. cms. (the pieces increasing in size by 10 cms. approximately), and the size of each written on the back. For a large class several sets should be prepared.

The class is now tested as in (*a*) above, in estimating the sizes of the larger pieces and of the pieces of varying shapes, on no occasion being told whether right or wrong.

The class is now divided on the basis of these tests by the method of "equal groups." One half of the class is now practised in estimating the sizes of the smaller rectangles until marked improvement appears. In this practice the subject should turn over each piece after he has made his guess and note the size. Final tests are now done by all (i) with the larger rectangles and (ii) with the pieces of various shapes, to see how far improvement has been "carried over."

Similar experiments may be planned:

(i) With series of weights.

(ii) With series of colour shades.

Experiment XXX.

A class is tested in speed of (i) addition of long columns, (ii) subtraction, and divided into "equal groups." One group now practises the method of multiplication used in the fatigue experiment (p. 82) until decided improvement appears. The performance of each two minutes should be noted and the percentage improvement reckoned. A final test is made in addition and subtraction to see what percentage improvement now appears in these. This experiment may be reversed, the first and last tests being done with the multiplication, and the practice with addition and subtraction done at top speed.

For a discussion of the results of these experiments see p. 216.

CHAPTER XIV.

THE SPEED OF READING AND ITS IMPROVEMENT.

Experiment XXXI.

Each student should first read something at normal speed, noting whether (i) auditory imagery, and (ii) motor imagery, or incipient movements of lips, tongue, and vocal chords, were very vivid, vivid, moderate, weak, very weak, or absent. Motor imagery and incipient movements of the kind mentioned are sometimes so difficult to distinguish that they are grouped together here.

Test I.

In a group experiment the instructor should now distribute to the class copies of newspapers, pamphlets, books, or any printed material of a simple type. Select the same portions for reading for all members of the class, and give them a two minute test of reading at full speed. Instruct them to read as fast as possible consistent with getting a full apprehension of the sense.

At the signal to stop students should write down observations as to auditory and motor imagery, and should count the number of lines read.

A second test should now be done with different reading matter (or at least different pages of the same book) and again the scores noted, and added to those of the first test, and an "order of merit" drawn up.

Test II.

Another test may be done with new material, subjects being this time warned that they would be asked to reproduce the substance of the material as far as possible. This test should be repeated with quite different yet simple material, to reduce the possible effects of special interests. Or better, give three tests of one minute each with different kinds of material. After the three tests, or after a further interval of definite length, the subject should write out from memory as much as he can remember of the three passages read.

Experiment XXXII.

Improvement of Speed of Reading.—The class should be divided into two "equal" groups (see p. 61) on the basis of Test I. in Experiment 31. One group should then practise speed reading for at least a quarter of an hour a day for several weeks Then another test similar to Test I, Experiment 31 should be given to both groups, practised and unpractised. If desired Test 2 of Experiment 31 may be used instead of Test I, before the practice period, but if so it must also be used after the practice period.

Each student should compare his records before and after the practice period: and the results of the practised group should be compared with that of the unpractised.

For a discussion of the results of these experiments see p. 218.

CHAPTER XV.

THE APPRECIATION OF POETRY, PICTURES AND COLOURS.

Experiment XXXIII.

(*a*) Read over the following poems at your usual pace:

"Five years have past; five summers, with the length
Of five long winters! and again I hear
These waters, rolling from their mountain-springs
With a sweet inland murmur.—Once again
Do I behold these steep and lofty cliffs,
That on a wild secluded scene impress
Thoughts of more deep seclusion, and connect
The landscape with the quiet of the sky.
The day is come when I again repose
Here, under this dark sycamore, and view
These plots of cottage-ground, these orchard-tufts,
Which at this season, with their unripe fruits,
Are clad in one green hue, and lose themselves
Among the woods and copses, nor disturb
The wild green landscape. Once again I see
These hedgerows, hardly hedgerows, little lines
Of sportive wood run wild. these pastoral farms,
Green to the very door; and wreaths of smoke
Sent up, in silence, from among the trees!

With some uncertain notice, as might seem,
Of vagrant dwellers in the houseless woods,
Or of some Hermit's cave, where by his fire
The Hermit sits alone."

"Beneath those rugged elms, that yew-tree's shade,
Where heaves the turf in many a mouldering heap,
Each in his narrow cell for ever laid,
The rude forefathers of the hamlet sleep.

The breezy call of incense-breathing morn,
The swallow twittering from the straw-built shed,
The cock's shrill clarion, or the echoing horn,
No more shall rouse them from their lowly bed.

For them no more the blazing hearth shall burn
Or busy housewife ply her evening care:
No children run to lisp their sire's return,
Or climb his knees the envied kiss to share.

Oft did the harvest to their sickle yield,
Their furrows oft the stubborn glebe has broke;
How jocund did they drive their team afield!
How bowed the woods beneath their sturdy stroke!"

Now note down as far as possible the mental processes involved in each case, especially any which seemed to contribute to the enjoyment of the poem.

(*b*) Repeat the reading of both pieces; this time note especially the extent to which visual and other imagery occurs, and the extent to which it contributes to the enjoyment of the poetry. Do not make any effort to obtain imagery.

(*c*) After recording results of (*b*), consider whether the mere suggestion that you should observe your imagery had not some effect.

(*d*) Finally re-read the pieces, this time making an *effort* to get as much vivid visual and auditory imagery as possible. Compare carefully your appreciation of the poems on the third reading with the first and second.

(*e*) After an interval (it may be after a few days) the poems are read again, without any effort to obtain imagery; but the effects of such previous deliberate imaging should be noted.

Experiment XXXIII. as a Class Experiment.

The lecturer reads the poems aloud to the class; they should not be asked to note their imagery until both poems have been read. (The first half of each poem may suffice.) Now proceed as under (*b*), (*c*), (*d*) and (*e*) above.

Alternative Form of Experiment XXXIII. as a Class Experiment

The class should be divided into two groups. One group reads the first (or some other) poem, and the other the second poem, freely without any constraint by further instructions. The various images experienced should now be noted as far as possible, and individual marks given to each image according to whether it was very pleasing (2), slightly pleasing (1), indifferent (0), slightly displeasing (− 1), or very displeasing (− 2). Then the groups exchange poems and this time each student attempts to get relevant visual or auditory images in reading the poem. Estimates as to the feeling value of the images should again be made. The *general* effect of the effort to visualise should also be noted. After a short interval (or after a day or two) the poems in the reading of which an

attempt to gain imagery was made, are read again, without any such effort; but the effects of the previous deliberate imagery should be noted.

For a discussion of the results of these experiments see p. 221.

Experiment XXXIV.

The Appreciation of Pictures.—(*a*) Select a group of a dozen or more reproductions of good pictures. (For class purposes some of the picture postcard series of famous pictures will serve.) Include one or two portraits. Take one of the pictures and look at it for a minute or two. Try to forget that you are experimenting, and give yourself up as completely as possible to the picture. Now write down whether you find it "very pleasing" (2), "slightly pleasing" (1), etc. (as in the preceding experiment) and give reasons for your judgment. (This is the Method of Serial Judgments.) Repeat the process with each picture. Now arrange the pictures in order of your preference. (Method of Serial Rank.) Now compare each picture with each of the others in haphazard order, recording your preference for each pair. (Method of Paired Comparison.)

You can now compare the orders of preference given by the three methods, and consider whether the act of comparing influences the aesthetic judgment.

Alternative Class Experiment with Pictures.

(*b*) For this experiment all the pictures should be coloured. Each student takes each of the pictures in turn, and records whether he finds it "very pleasing," "slightly pleasing," etc. (as above), adding reasons; for each picture he should number the various factors which have influenced him according to his estimate of the strength of their influence: thus, (1) colour, (2) beauty of composition, (3) interest of subject, etc.

The results of the class members should be compared to discover

(1) individual differences in the attitudes towards the same pictures,

(2) whether some are chiefly influenced by colour, or meaning, composition, etc.

For a discusssion of the results of these experiments see p. 222.

Experiment XXXV. The Appreciation of Colours.

(*a*) Select a dozen patches of coloured paper of similar shape and size but of different colours Take one at a time and place it on a neutral background. Then ask yourself "Do I like this or not—and why?" Record your judgment and reasons.

For a discussion on the results of this experiment see p. 223.

Experiment XXXVI.

The Testing of Aesthetic Development.

I. *Testing Appreciation of Pictures.*

Rough estimates can be made of the stage of development reached by children or adults in the aesthetic appreciation of pictures in two ways.

(*a*) First, we can examine the *types* of judgments given in Experiment XXXIV. (*b*) classifying them according to the types given in the discussion on the colour experiment (XXXV.) in Part II., page 223.

Mr. E. Bullough, who first classified these types, using colours, gives good grounds for listing them in the following order from the point of view of genuine aesthetic appreciation. Elsewhere I have given reasons for a very similar order (also given below) in the appreciation of

musical intervals and for their significance in judgments on pictures.[1]

Bullough's Experiments with Colours.	*Valentine's Experiments with Musical Intervals.*
1. Character.	1. Character.
2. "Fused" associations.	2 Musical (fused) associ-
3 Objective.	3. Objective. [ations.
4. Non-fused associations	4 Subjective.
5. Subjective (or physiological.	5. Associations other than musical (non-fused)

The difference between the fused and non-fused associations may be indicated by saying that the latter are very personal and non-essential: as when a student disliked a colour because it was the colour of a tie habitually worn by a teacher she disliked. Personally I should put this type as lower than the subjective. The use of these types of judgments, however, must only be regarded as suggestive indications of aesthetic development: and very young children are apt merely to repeat things they have heard others say. A more objective and dependable test is the following[2]:—

(*b*) Select about half-a-dozen good reproductions of pictures which have long been widely recognised as masterpieces; three or four by modern painters of wide repute; three or four by artists of mediocre reputation; and three or four that you consider really bad. Arrange these in an

[1] See *Experimental Psychology of Beauty* (2nd Edit.), p. 101; also "A Study of Individual Differences in Attitude towards Tones" by C. S. Myers, with contributions by C. W. Valentine, *Brit. Journ. of Psych.*, VII., 1914, pp. 100, 101.

[2] Based upon Burt's test described in *How the Mind Works*: Edited by Cyril Burt, page 289.

order of merit with the help of several friends with artistic training Now ask the children to arrange these in the order in which they prefer them. The degree of resemblance between the child's grouping and that of the experts' gives some measure of his aesthetic judgment. The resemblance can be calculated by the method of correlation (Chapter IX.). Of course, this assumes the reliability of the standard order, and that everyone 'ought' to like the same pictures; and with neither of these assumptions can the present writer agree, even if the standard order is arranged by artists or expert critics. If, however, the extremes of good and bad pictures are made sufficiently wide apart, it is possible to detect at least a very crude and uneducated taste, and this will also be brought out by the reasons for preference.

II. *Testing Appreciation of Poems.*

A similar test may be done with short poems. Select and make copies of half-a-dozen recognised masterpieces —say sonnets from Shakespeare, Wordsworth, Rupert Brooke, brief poems by Shelley or Keats, and half-a-dozen crude poems taken from cheap popular magazines or newspapers. The subjects should be asked to arrange these in three groups: (1) those they like very much, (2) those they like slightly, (3) those they do not care for at all, or actually dislike; or the poems can be arranged by each subject in an 'order of merit,' and compared with one based on the judgments of several persons of 'cultivated literary tastes'—admittedly a vague and variable thing.

For a discussion of the results of these tests see page 224.

CHAPTER XVI.

ACCURACY OF REPORT.

Experiment XXXVII.

For this experiment a partner or a group of students is necessary; or the experiment may be tried with a class of children.

Select a coloured picture. If it is a class experiment the picture should be large enough to be seen clearly by the whole class. The kind used for oral lessons in elementary French would do well. There should be a good number of objects and several incidents depicted.

Tell your subject (or class) that you are going to show him a picture and then ask questions about it to see how much he can remember.

Expose the picture for half a minute, if it is large and complicated, or rather less, 15 or 20 seconds if it is a relatively simple one.

Then remove the picture and ask your subject to write down answers to your questions It is better still if you can introduce an interval between the exposing of the picture and the questioning: *e.g.* another experiment might be done, or the picture might be exposed at the end of one lecture and the questions asked at the beginning of the next provided for experimental psychology.

The questions should be of the following type: some of them (marked * below) are deliberately introduced to see if the subject is misled through suggestion: but others are straightforward and refer to actual facts.

(1) How many people are shown in the picture?

(2) What was the man doing?

(3) What colour was the woman's hat? (* she had no hat).

(4) Was there a motor car in the picture?

(5) Where was the dog standing? (* there being no no dog).

(6) What kind of a shop was on the left?

(7) Was there a lamp post in the picture? (* there being none).

At least 25-30 questions should be given, the majority of which should not be deliberately misleading, otherwise the subject may soon suspect he is being misled. (No. 4 above would not count as an actually misleading question even if there were no motor car; but to some extent it is suggestive).

It will be seen that some of the 'suggestive' questions are more strongly suggestive than others: for example. 'What colour was the woman's hat?' (when there was none) as compared with 'Was there a lamp post?' in the picture?' The former *implies* that there was a hat.

For a discussion of the results of this experiment see p. 227.

CHAPTER XVII.

PERCEPTION, APPERCEPTION AND IMAGINATION.

Experiment XXXVIII.

Prepare a set of a dozen or more ink-blot figures by making a large blot on the inner fold of a quarto sheet of paper, and then pressing the sheets together. A few non-symmetrical splash blots should be added. Number the sheets. Now take one at a time, look at it steadily for a few moments and record what it looks like to you. After completing the set compare your results with your partner's.

For a class experiment, the blots should be made extra large so that they can be held up by the lecturer and seen clearly by the whole class.

CHAPTER XVIII.

INTUITIVE JUDGMENTS OF CHARACTER DISPOSITION AND INTELLIGENCE.

Experiment XXXIX

The Judgment of Character shown in Photographs. —The experimenter collects a dozen or so photographs of persons, including if possible some really good portraits of persons well known to him. He may also include some of saintly philanthropists, not too well known, and swindlers or cold-blooded murderers if procurable, in a similar form. The portraits should all be numbered, but no name should appear. The subjects are now asked to express a general judgment on the character of each person portrayed; and then to give a mark for each of the following traits, on the scale shown.—

Traits: Temper, conscientiousness, kindness, self-assertiveness, straightforwardness, intelligence

Scale:

A.	B.	C	D.	E.
Very good or Very strong	Good or strong.	Moderate or Average.	Weak or Bad.	Very Weak or Very bad.

Subjects may also be asked whether they like the person in the photograph, and to underline any judgments of which they are specially certain.

The results of different subjects can now be compared with one another, and with such facts as are known to the experimenter. A student working alone can collect the judgments given by friends at various times. Even if the photographs are not really exact ones, the experiment will reveal individual differences of judgment.

Experiment XL.

The Judgment of the Characters of Children.—A better experiment than the last can be done if a few children can be secured on whom detailed reports on character can be given by teachers who have known them well for a year or two. The teachers (preferably two or three in collaboration) give marks on the scale suggested above, on character traits and intelligence. If a class of students is to do the experiment they can be divided into groups of about half-a-dozen; each child goes in turn to each group for five minutes and the group ask him any questions they like, *e g.* as to his interests, what he is going to be, etc, but not including actual intelligence tests. When the child leaves the group each student (without any discussion in the group) *independently* records for him a mark for each trait on the scale given above. Finally the scores of each student are compared with those given by the teachers.

A student working alone can easily adapt the above experiment to his own convenience.

When teachers' estimates are asked for, a 'guiding' list of definitions of the various terms should be given somewhat as follows.—TEMPER—Very good (A)—means that even under severe provocation or constant irritation by others, the child does not get angry (except in *extreme* cases) and never sulks.

Bad (E)—means loses his temper on very slight provocation, or goes into prolonged sulks.

Similar definitions should be drawn up for the other qualities, and teachers asked to keep the extreme marks A and E only for very exceptional cases.[1]

For a discussion of the results of these experiments see p. 231.

[1] A list of suggested definitions is given in the Appendix C of the paper referred to in the discussion on this experiment (Part II, p. 232). In Appendix A is given a method of calculating the correspondence between the teachers' estimates and those of the judger.

CHAPTER XIX.

THE GROWTH OF CONCEPTS.

Experiment XLI.

The Growth of Concepts.—This experiment should be done either (1) as a class experiment, the instructor reading the instructions, or (2) individually, in which case the student, after performing the experiment described below on his partner, should get the partner to prepare for him a similar experiment differing in detail. The instructions below are given as a class experiment. The adaptations needed for a pair of workers will be easily seen.

(1) For the experiment are required several small sets of pictures. Picture postcards will serve the purpose. For a class of about twenty prepare five sets of five pictures each. One set may be pictures with animals in them; a second, water scenes or modes of travel; a third, pictures with children in them, and so on. That is, each set is to have some characteristic common to all its members. It is useful also to include one set of geometrical figures having some common quality. There must be a card for each member of the class, plus about half-a-dozen over.

(2) Give a nonsense name to each type of picture, writing the given name on the back of each. The following names and sets were used in my own experiments :—

FUNEP	pictures with animals in them,
GAZOD	water scenes (sea, lake and river),
BENEP	coloured pictures of various types,
ZAVOS	pictures with children in them,
BATFUD	pictures of buildings (ruins and modern buildings).

The class is told that there are groups of pictures, and that each group has a name given to it which has to be learned as the group is discerned.

(3) Shuffle the cards. Let each member of the class have one before him face upwards. At a given signal each should turn his card over and read the name. After 15 seconds give the signal to pass the cards on to a neighbour, so that the cards circulate all round the class. The operator will leave two or three cards in a pile by student No. 1 (for him to take as he needs them), and will collect the cards given up by the last student, transferring them from time to time, and in order, to the pile in front of student No. 1. Proceed thus until all the cards have been seen by each student.

(4) Get students to write down their introspective remarks on ideas that have been forming in their minds.

(5) Read out the nonsense names one at a time and ask students to write down what the name means to them.

(6) Repeat (3), (4), and (5), this time adding the following test:—

Test A.

Read out these incomplete sentences, asking students to fill in the blanks appropriately:

All gazods are . . .
No benep is . . .
All funeps have . . .
Every zavos has . . .
All batfuds are . . .

(7) Now suggest the following points for observation by students before repeating the experiment:—

How did the growth of a general concept or idea of a group begin? Was it at first too wide or too narrow? Was it attached to special pictures? Was it hindered by confusion through similarity? How did images function? When were they clearest? How did they change? Could you *use* a concept (*e.g.* filling in the word in Test A) without being able to define it?

(8) Repeat (3), (4), and (5), this time with the following variation of Test A:—

TEST B.

This gazod is . . .
One benep is . . .
The best funep is . . .
This zavos is . .
One batfud was . .

Note any further points brought out by (8) and Test B in the light of the questions under (7).

For a discussion of the results of this experiment see p. 233.

CHAPTER XX.

EXPERIMENTS ON THOUGHT PROCESSES.

The experiments in this chapter will not only serve to introduce the student to the difficult study of the thought processes, but will familiarise him with some fundamental ideas underlying certain useful tests of general intelligence, especially the opposites, analogies, and reasoning tests.

Experiment XLII.

Associations Restricted and Guided by Relationships.—These experiments may be done by the student alone, but it would be better to obtain a partner and have the stimulus word read out and the length of reaction time measured by means of a stop-watch, or roughly by the method described on page 13; or the experiments may be done as group experiments, the class dividing into pairs, with individual time measurements.

The subject should write down any introspective observations after the reactions, seeking especially to discover what mental processes have taken place in cases where the reaction has been unusually prolonged.

(*a*) *Whole and Part Associations.*

Each of the following words is the name of an object. As you read (or hear) each word give the name of some *part* of the object, *e.g.* horse-tail; house-window.

chair library army jury piano face town hand world Parliament University Fleet

(*b*) *Species-genus*,

Give the name of the wider class to which each of the following belongs.

horse	table	pistol	cabbage	bicycle
Kitchener	Daily Mail		school	honesty

(*c*) *Opposites Test.*

Give the opposites to the following. As before, if possible, have the speed measured by a partner, and write full introspective notes. Note especially any changes in mental processes as you proceed through the series. Read from left to right.

good	heavy	dark	ugly	healthy
loquacious	yielding	aggressive	pampered	

For a discussion of the results of these experiments see p. 236.

Experiment XLIII.

The Analogy and other Relationships in Thought Processes.

Analogies.

Get both experiments (*a*) and (*b*) read out to you by a partner, and the time of your responses measured by a stop-watch or by the method described on page 13.

(*a*) The first two of each set of three words are related to one another; a fourth word has to be given which bears a similar relation to the third as the second does to the first, thus—Good is to bad as Day is to Night—the relation here being that of opposites. As before, give any account you can of the processes which take place in giving each response.

army : navy :: soldier :

cold : hot :: North Pole :

executive officers : government :: hand :

man : woman :: mathematics :

(*b*) Give two ideas bearing to one another a similar relation that the three given pairs do respectively.

(i) Summer : autumn : ·

(ii) Life : death : ·

(iii) Water : ice : :

(iv) Think of two politicians of whom one is to the other as Red is to Blue.

(v) Think of two authors of whom one is to the other as thunder is to the rippling of a brook.

(*c*) *Apprehension of Relationship and of Related Ideas.*

(i) "Where the carcass is there will the eagles be gathered."

This may be expressed in the abstract form—

"Wherever you find x you find y."

Give a further example to illustrate this relationship.

Write two statements involving similar relationships to each of those expressed in the following formulae. One statement should refer to human affairs—the other to the world of nature.

(ii) X's superiority to Y is greater than Y's superiority to Z.

(iii) If X shows the quality A, B is also present.

Express in an abstract formula the relationship involved in the following, and then write another example.

(iv) Of all superior students the superior medical student is the most superior.

(v) As your income increases relatively to your expenditure so your happiness increases.

For a discussion of the results of this experiment see p. 238.

EXPERIMENT XLIV.

Problems in Reasoning.[1]—(i) If equals are added to unequals are the results unequal?

(ii) If the train was late he would miss his appointment: if the train was not late he would miss the train. We do not know whether the train was late or not. Can we tell whether he kept his appointment?

(iii) John said. "I heard my bedroom clock strike yesterday, ten minutes before the first gun fired. I did not count the strokes, but I am sure it struck more than once, and I think it struck an odd number." John was out all that morning, and his clock stopped at 5 to 5 the same afternoon. When do you think the first gun fired?

(iv) Captain Watts and his son James have been found shot—the father in the chest and the son in the back. Both clearly died instantaneously. A gun fired close to the person—as, for example, when a man shoots himself—will blacken or even burn the skin and clothes: fired from a greater distance it will leave no such mark. The two bodies were found near the middle of a large hall used as a rifle range. Its floor is covered with damp sand which shows every footprint distinctly. Inside the room there are two pairs of footprints only. A third man, standing just outside the door or window could aim at any part of the room: but the pavement outside would show no footmarks. Under Captain Watts' body was found a gun: no such weapon was found near James. In each case the coat, where the bullet entered, was blackened with gunpowder, and the cloth a little singed. Captain Watts was devoted to his son, and would have died sooner than harm him purposely: hence it is impossible to suppose that he

[1] The second, third, and fourth are selected from Dr. C. Burt's Reasoning Tests, the second being slightly amended.

killed him deliberately, even in self-defence. But some think that James secretly disliked his father, and hoped to inherit his fortune at his death. (1) Was Captain Watts' death due to murder, accident, or suicide? (2) Was James' death due to murder, accident, or suicide?

(v) Do International Congresses (*e g.* the World Congress of Advertising at Wembley) help international relationships?

For a discussion of the results of this experiment see p. 239.

CHAPTER XXI.

TESTS OF GENERAL INTELLIGENCE.

Experiments XLV, XLVI., and XLVII.

There are given below further examples of tests which, in addition to the analogies and reasoning problems of the last chapter, have also been found to correlate highly with general intelligence. The student should read the section on the nature and purpose of intelligence tests (Part II. p. 240) before doing the experiments.

While mental tests are mainly intended for use with children, if they are to be so applied it is highly desirable that the experimenter should first undergo similar tests himself, in order that he may realise better what is involved in the performance of them. It is not suggested that these few tests are adequate for showing the intelligence of adults.

Experiment XLV.

Completion Test.—Fill in the blanks in the passage given below so as to make the whole into a consecutive and sensible piece of prose. A time limit should be given, say fifteen minutes. When a whole class are doing the experiment it should be stopped when about half have completed as much as they can. The whole paragraph should be read over before the filling in of blanks is begun. A blank usually indicates the omission of several words.

Piece A.

About three-fourths ..... England belong to the wage-earning..... .., and.... ...events when.....fed, ...housed and educated, they have their fair..... that nervous energy which is.....material of business ability. Without. .....of their way they are all..... or unconsciously competitors for.....of business command. The ordinary workman if.....ability, generally .....foreman, from..... to be a manager and to be taken.....with his employer. Or having.....a little of his own.....start one of those small shops which still.....their own in a working man's quarter,..... chiefly on credit, and.....wife.....by day while he gives.....to it. In.....or.....ways, he may..... capital till..... small workshop or factory. Once .. ... . good beginning he.....banks eager.....credit.

The full passage is printed on page 243. Each blank suitably filled in should score one mark. Of course the words given in the full passage are not the only ones which will satisfactorily fill the blanks. The student must be careful, however, to mark only for words which not only make sense of the sentences in which they appear but which are also consistent with the passage as a whole.

Piece B. Conjunction Completion Test.

The spaces in the following passage are to be filled in by such connecting words as "even," "for example," "indeed," etc. "*And*" *must not be used* Use the word which brings out the sense most fully. Make a list of the words each with the number of the space it is to fill. The test may be stopped when half of the class have finished. All should start together, the exact time being noted by the lecturer. Each should indicate when he finishes, and the lecturer can tell him how long he has taken.

The Daily Press.

The development of the daily press is of great social significance In the first place the daily paper costs only a tithe of what it did a century ago and ..... (1) it is purchased by a vastly greater number; .....(2) it has been stated that ..... (3) in the poorest districts in London on the average one paper is bought per day for every family. .....(4) this does not indicate the full extent of publicity; .....(5) many a poor man peruses two or three newspapers the same evening at a public reading room. It has been argued that this wide publication is essentially democratic, ... (6) in the long run the views supported by the majority will obtain the widest publicity; and there is some truth in the contention, ... (7) no paper could continue indefinitely if it advocated views strongly opposed by the majority of its readers. .....(8) there are serious limitations to the extent to which this is true; .....(9) a modern paper depends financially more on its advertisements than on the money paid by subscribers. ..... (10) if a newspaper can get a circulation among a well-to-do purchasing public, ... (11) if limited in number, it will attract advertisements and.....(12) it can afford to offer special attractions to induce those who do not agree with its politics to purchase it.

See p. 244 for a discussion of the results of this experiment.

Experiment XLVI.

Apprehension of Numbers.—Each of the squares in Fig. 6 contains a group of dots varying in number from four to nine. A series of similar squares should be marked

out on paper, enough to make with those in the figure a total of thirty squares. Each group of dots should appear an equal number of times, but the order should be varied. Let your partner use the set of squares that you make, you using the set that he has prepared.

The task is to apprehend the number of dots in the successive squares as rapidly as possible, calling the numbers out aloud to your partner.

Your partner must take down what you say, in order that your accuracy may be tested subsequently.

It should be clearly understood that the dots are not to be counted individually any more than the student finds necessary. As far as possible the group should be apprehended as a whole or as an arrangement of two or more minor groups each of which can be taken in at a glance.

Your partner should also time you, and note down the number of seconds required to do all the thirty squares.

If a whole class are doing the experiment they should work in pairs as above. The test should be stopped when any student has finished. One mark is to be reckoned for each group of dots correctly apprehended.

The partner now becomes the subject, the previous subject noting down his answers as above. The same length of time should be given as was taken by the first subject (or by the first section of the class).

If a comparison of results is desired proportionate allowance should be made for any student of the second group who finishes the test before the allotted time is up.

For the *application of the test to children* it would be well that the squares of dots should be marked upon cards Each card may contain several squares; eight on a card would make a convenient size. As each card is finished with, it is to be removed, and the groups of dots on the next card proceeded with straightway. This is a test

Apprehension of Numbers.

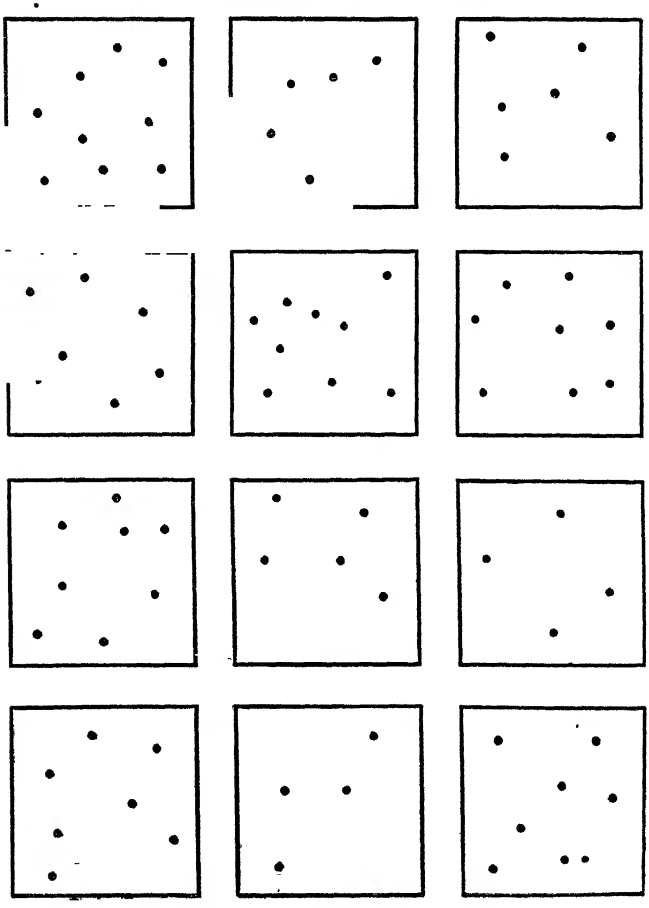


Fig. 6.

which can only be applied satisfactorily to one child at a time, and the same set of cards should be used for all the children whose performances are to be compared.[1]

See p 245 for a discussion of this experiment.

Experiment XLVII.

Miscellaneous Tests for Adults.—These should first be worked at full speed. A time limit should be set to each test by stopping the work as soon as one member of the class has finished a test, notes being taken of the amounts completed by that time. The test can then be finished by each at leisure, and the results of the "speed" and "unlimited time" tests compared.

(*a*) Continue each of the following series of numbers for three places:

1	3	5	7	9	11.....
9	1	7	1	5	1... .....
3	4	6	9	13	18.....
4	8	10	20	22	44.....
1	5	13	29	61	.....

(*b*) In the maze (Fig. 7) the subject has to trace the path with a (dry) pen from the centre to the outside without a false turn. If one false turn is made the subject must start at the beginning again. The path may be experimentally explored by the eye beforehand, without pointing.

[1]Dr. C. Burt, from whom I borrow this test, used a pack of fifty cards, only one group of dots being on each card. The children had to deal the cards, calling out the number of spots upon each as they went along. The test correlated with estimated intelligence to the extent of 0·64, the reliability coefficient being 0·91. *See Journal of Experimental Pedagogy*, Vol. I., p 102.

The score is 4 if no false turns are made, 3 if one is made and so on.

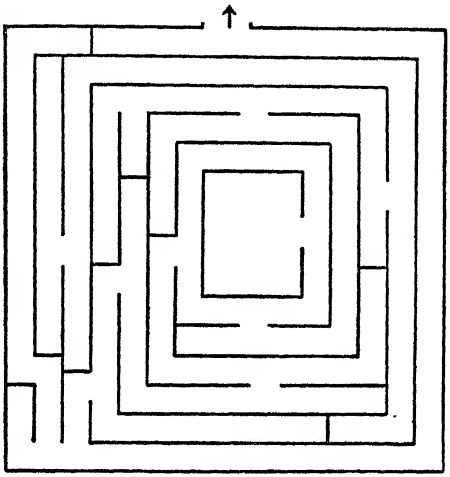


Fig. 7.

(*c*) A copy of the same picture postcard is provided for each member of the class and cut up previously (all cards on the same plan) into a score or so of pieces. Each set of card pieces is well shuffled before being placed before the student. A whole card is shown to the class for half a minute and then all start to rearrange their card pieces correctly. The test is stopped when one student has finished; the others score two for each piece correctly placed: half if joined to a fellow but detached from the main group.

(*d*) Below are some mixed-up sentences, some true and some false. At a given signal consider the first line, form the proper sentence in your own mind, and if it is true

underline the word *true* opposite to it; if false underline the word *false*, thus:

All it invariably England August is fine in.....true false

Are food of staple potatoes the the Irish poor.....true false.

People enemies arrogant many make.....true false.

England teacher education a has in school an in every elementary University... ..true false.

The lecturer should make a list of 20 such sentences and get the students to do them as fast as possible, the time taken being indicated to each student as he finishes.

(*e*) A list should be made by the lecturer of difficult analogies (see p. 117) and opposites, to be done at speed by the class.

See p 246 for a discussion of the results of these experiments.

CHAPTER XXII.

TESTS OF MANUAL DEXTERITY.

Experiments XLVIII., XLIX., L., LI., LII., and LIII.

The following tests may be used to study abilities of a more practical type than those involved in the Intelligence Tests and the other experiments in this book. They are, indeed, largely tests of specific motor abilities, though intelligence may enter in at times. They may also be used in considering the question whether there is such a thing as a *general* manual capacity.

Experiment XLVIII.

Packing Matches.—A box containing fifty matches is provided for each pair of partners. The matches are emptied and arranged in an irregular heap. At a given signal one partner begins to replace the matches in the box, with heads on the far inside, his partner timing him. The latter partner now does the test. The first partner repeats the test and so does the second. An average score of two (or three) tests is taken and an order of merit for the class obtained.

A similar test may be done with the left hand.

Experiment XLIX.

Hitting Targets.—(i) Each subject has Figure 8 opposite him on a table at arm's length, and a pencil

in his hand. Each subject holds the pencil touching his right shoulder and at a given signal stabs the first circle in the centre with the pencil point, bringing back the pencil to the shoulder and then marking the second circle. The experimenter taps on the desk (two beats a second) the subjects touching the shoulder at one beat and hitting the target at the next, and so on. A preliminary practice (using the blunt end of the pencil) should be done till all understand the method clearly. When the series is completed the test should be repeated. If less than two dots appear in a target one may be assumed to have impinged on the other. The score is now reckoned:—0 for outside the ring, 1 for a dot within the outside ring, 2 for the ring second from the outside, and so on. The scores are added up and an order of merit obtained and compared with that for experiment XL.

(ii) Using now a different instrument (a big needle to make holes with) repeat the experiment but this time start with the needle in the centre disk of the middle row: move it to the first disk, then back to the middle disk, now to the second, back to the middle, and so on. The order of merit is then compared with that of (i).

Experiment L.

Card Sorting.—Each pair of partners has two sets of cards or pieces of paper clearly distinguishable, *e.g.* one set coloured or marked, the other plain, and about 25 of each. These are mixed in a heap in front of the subject. At a signal he sorts them, picking out the plain cards with his right hand and the coloured ones with his left, placing the first to the right and the second to the left. The partner notes the time taken.

The order of merit is compared with those of the preceding experiments.

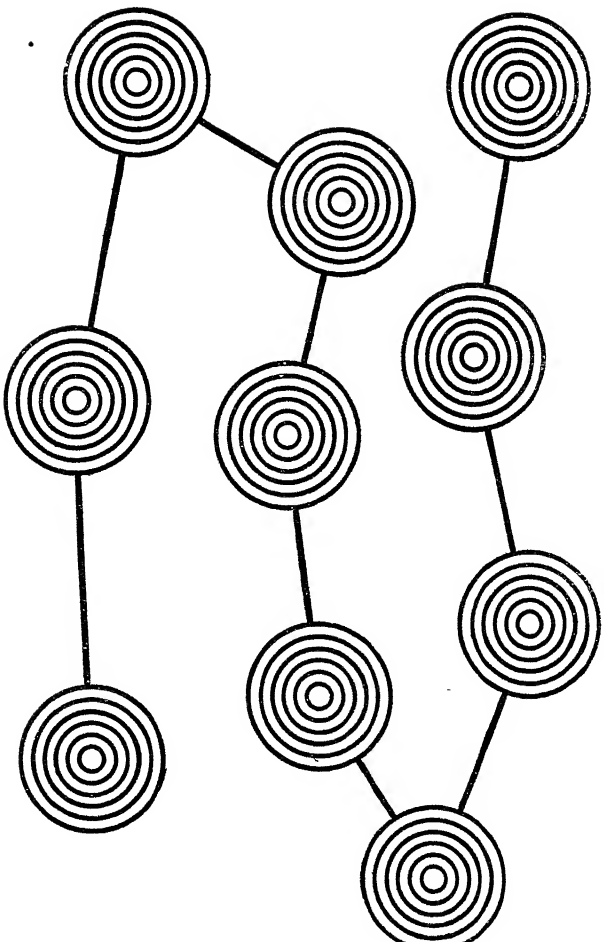


Fig 8.

Experiment LI.

Form Board.—From a sheet of thick, stiff cardboard, or better of wood, about the size of a foolscap sheet, cut out a dozen pieces of varying shapes—squares, rhomboid, ellipse, cross, circle, etc. These shapes are mixed in a pile and the subject, at a signal, fits them one by one in the appropriate spaces, the time being noted. An average of two or three attempts is taken. Each student is tested and the order of merit drawn up and compared with those of the preceding experiments.

Experiment LII.

Interference of Physical and Mental Activities.—Each partner prepares a series of twenty squares of the height of the space between the two lines of a foolscap sheet of ruled paper and one inch apart. The subject, at a given signal, says the eight or nine times table as quickly as possible, the time being noted by the partner. He now repeats the table, this time putting a dot in each of the squares as he does so. The time is noted. The table is repeated again (alone) and the average time of the first and third tests compared with the second. The second test should be repeated in a more difficult form, the letters *a*, *b*, *c*, *d* being inserted in the squares, but this makes the physical activity involve mental work to a greater extent. It must always, of course, involve some mental work.

Experiment LIII.

Steadiness of Hand Movement.—Each pair of partners has a box of large matches, not rounded (the large Bryant and May's safety match is suitable). Two matches are placed parallel, rather less than a match length apart, and two placed across them, one at each end: others are added similarly till there is a tower 12, or

if possible 15, matches high, containing 24 matches or more. At a given signal the subject now, with the small blade of a pocket knife, removes the matches one by one till the bottom pair is reached. Each match must be lifted clear of the others. If it is pushed over the edge it does not count. Each subject is timed and the best time of three attempts taken. If no attempt is completely successful the best is considered, and one error (if there are, say, 22 matches to be moved) adds $\frac{1}{11}$th to his time score. The other partners now do the test and an order of merit is drawn up.

Correlations of the various orders in the above experiments may now be calculated.

See p. 265 for a discussion of the results of experiments in this chapter.

PART II.

CHAPTER I.

IMAGERY.

EXPERIMENTS I. AND II.

It is, of course, very difficult, perhaps strictly speaking impossible, to say whether a visual image is more or less vivid than an auditory image. But if the reader will repeat the tests of Experiment I with various imaged objects he will soon get an idea as to where his imagery is strong and where it is weak.

People vary enormously in this respect. Many, for example, will find that they can get no images of taste or temperature or even of smell. Educationally the most important kinds of imagery are visual and auditory. The subsequent experiments on memory will bring out more clearly the use of such imagery in memory work.

The student should also observe carefully the various ways in which imagery may be of service in every-day life, *e g.* in recalling the appearance of a map and so more easily finding one's way about a strange town, in deciding on a colour scheme for a room or a costume, or in recalling the tone in which a person said something in order to decide whether it was meant in a friendly way or not. He

should observe also the way in which he uses imagery in his continuous thinking.

The uses of imagery already mentioned, and others which will appear in some later experiments, would seem sufficient to make it undesirable that it should be allowed to decay.

There is considerable evidence to show that the power of imagery may be cultivated by practice and lost through neglect. Thus children in general seem to have vivid visual imagery,[1] and so have most women. Many men, however (most of whom find it less useful than women do and therefore practise it less), have only vague visual images, especially men who are much given to abstract thought. But artists and others who practise imagery retain the power of vivid imagery.

Those whose visual imagery is much more vivid than the other kinds are said to belong to the visual type and are called "visiles." If the sound images are much the most vivid they belong to the auditory type and are called "audiles." Most people seem to belong to a mixed type.

Among normal adults vivid auditory and kinaesthetic imagery is very common.[2] Among backward children, however Burt found only 9% were audiles while 55% were predominantly visualisers.[3] Children with no "inner speech" were also far commoner than among normal

[1] It may be worth while for the teacher to bear this fact in mind. "The teacher who can himself image clearly when he wishes will often find in doing so a key to the minds of the children whom he has to instruct."—Loveday & Green, *Introduction to Psychology*, p 177.

[2] C. Fox found them about as frequent as vivid visual imagery. (See his *Educational Psychology*, p. 77.)

[3] See his book *The Backward Child*, pp. 516 518.

children. Burt emphasises the importance of the testing of the imagery of backward children, for concrete imagery seems to play a more important part in their thinking, in spite of the frequent vagueness of the images.

Control of Imagery.—In Experiment Ib interesting individual differences occur. Some persons have much more control over images than have others. Some can increase a line gradually, others only "in jerks." Not all can keep a square red when yellow is suggested: one student's red square turned orange: others saw a yellow square in the margin of the board, the red being retained. Some find imagery insistent, and cannot inhibit it.

There is evidence of some connection between the capacity to visualise and the ability to do geometrical problems.

Spontaneous and Voluntary Imagery.—It is important to note that the instruction to observe imagery usually increases the tendency for imagery to occur. Our experiments have tested chiefly the possibility of deliberate imagery. The results should be compared with those gained by reflecting on the appearance of imagery in mental processes in every-day life.

Later experiments on Memory, the Use of a Map, Thought Processes, The Speed of Reading and The Appreciation of Poetry will afford further opportunities of the study of imagery.

CHAPTER II.

ASSOCIATION AND REPRODUCTION OF IDEAS.[1]

Experiment III.

Factors Determining Association or Recall.—The general law of the association of ideas may be briefly expressed as follows: when two ideas, A and B, have been connected by unity of interest, or when they have been attended to together, they tend to recur together, *i.e.* if A recurs it tends to call up B, and vice versa.

There are certain conditions or factors which help to determine whether such an association will be strong or weak, whether it will last for a long or only a short time, and the likelihood of its recurrence. For example, the more frequently we attend to A and B together the stronger the bond between A and B becomes; the greater our interest in A and B, and the more unified, the stronger will be the bond of association, and the more recently we

[1] In connection with this chapter the student is recommended to read some general account of association, *e.g.* Stout, *Groundwork of Psychology*, Chapters VII. and XI ; McDougall, *Outline of Psychology*, Chapter XV ; Stout, *Manual of Psychology*, Book IV., Chapter I. ; James, *Principles of Psychology* Vol. I., Chapter XIV.

have attended to A and B together the stronger is the association likely to be at the present moment.

Now a given idea may have been connected with many ideas at different times in our past experience. Thus the word *book* has been associated with many different books. When the word *book* is seen there may therefore be a competition, as it were, of various associations each striving to come into consciousness. Why is a certain one victorious over the others? Why did the word *book* call up exactly the idea it did in this experiment?

To explain this we must refer to those factors or conditions which affect the strength of associations and help to determine what ideas are recalled.

We select five of the most important factors. Probably it will be found that most of the associations the reader obtained in the experiment can be explained by reference to one or other of these factors. It should, however, be remembered that the list is not exhaustive.

(1) **Recency.**—Apart from the influence of other factors to be mentioned presently, an idea tends to recall that idea with which it has been most recently associated. Thus, *book* is likely to suggest the book you have most recently been reading, perhaps this book itself.

(2) **Frequency.**—Apart from the influence of other factors an idea tends to recall that idea with which it has been most frequently associated in the past.

This factor may overcome the influence of recency. Thus in response to *green* you may have thought, not of the last green thing you saw, but of grass, because of the great frequency of the association of grass and greenness.

Of course it is possible that these two factors should act together and support one another. Thus if grass happens to be the last green thing I have seen, as well as the one I

have seen most frequently, it is still more likely to be thought of when the word *green* is presented.

(3) **Intensity of Interest or Feeling at Time of Formation of Association.**—Other factors apart, an idea tends to recall the thought of some thing or experience which was associated with it in the past and which was exceptionally interesting. In other words, the more intensely interesting a certain experience is, the more likely is it to be retained in the memory and the more readily will it be recalled Thus, if I had a serious operation ten years ago, I am quite likely, in response to the word *doctor* in the experiment, to think of the doctor who performed the operation, even if I have seen other doctors more recently and more frequently.

Again, it is possible that all these three factors will act together in some cases. Thus *bicycle* may suggest my own latest bicycle, which I have seen and ridden more recently and more frequently than any other bicycle, and the one on which I have had my most enjoyable rides or a very exciting accident. On the other hand, this factor of Interest may conflict with one or both of the two previous ones. I may have had an accident when I was riding a friend's bicycle, and this may now be thought of when I see the word *bicycle*, although I have ridden my own bicycle more frequently and more recently.

These three factors of Frequency, Recency, and Intensity of Interest all concern the past. But the conditions present at the moment of recall or reproduction also act with them in determining the line that association shall take. This leads us to mention a fourth factor.

(4) **The General Trend of Mental Activity at the Time of Recall.**—"Those objects tend to be ideally reinstated which are relevant to the general trend of mental

activity at the moment of recall. If our minds are occupied with scientific discussion the word *proofs* will suggest one group of ideas; if we are engaged in preparing a book for the press it will suggest something quite different." [1]

In Experiment III the word *friend* may start me thinking about a certain friend. Then the word *bicycle* may determine that I should think of my friend's bicycle.

We can arrange conditions in such a way that the effect of this general trend of mental activity is very clearly shown. Thus by arousing certain ideas in the mind of a person we may be able to determine the line on which associations shall take place. Suppose, for example, that I talk to a class of children about country fields, and cows, and the danger of getting tossed, and then show the children the letters B–LL, they are likely to think of "bull." If, on the other hand, I talk to them of the coming of summer and cricket, they are likely to complete the word so as to read "ball"; while if I say to the children that it is nearly twelve o'clock and time to go out of school the letters are more likely to suggest "bell." [2]

(5) **Dominant Interest.**—We have seen that the general trend of mental activity at any moment helps to determine what associations shall take place at that moment. Now I may become interested in some topic to such a degree that there is a constant tendency for associations to take place in a way that fits in with that special interest, even when I am not at the moment concerned with it.

Suppose my chief interest is in psychology. Then the word *book* is quite likely to suggest a psychology book, even

[1] Stout, *Manual of Psychology*, 3rd edition, p. 565.

[2] In these examples we have approached the topic of Apperception; an experiment bearing on this subject is described in Part I. Chapter XVII.

though I have read other books more recently and more frequently, and though at the moment when I see the word *book* I am not thinking about psychology. This last fact indicates the distinction between factors IV. and V.

Furthermore, there may be other books, novels perhaps, which I have found more intensely interesting as individual books than any psychological books. But they are not linked together by a wide dominant interest as is my psychological reading. Herein appears the distinction between this factor of Dominant Interest and factor III., Intensity of Interest.

Classification of Associations.—The student should now attempt to classify the associations he observed in Experiment I. as exemplifying one or other of the factors mentioned. In most cases no doubt he will find that more than one factor has been at work. Some associations he may not be able to classify at all, for the list, as already stated, is not exhaustive.

In particular the following type of reaction may occur. 'Bicycle' may give rise to 'train' with or without a vague thought of a bicycle as a mode of transit, and thence 'train' as another mode.

Now this may be regarded as a recall of a series of three ideas, *a*, *b*, *c*, of which *a* and *b* have been previously associated, and likewise *b* and *c*, though in some cases *b* does not rise to consciousness—a kind of 'short-cut' process. Some psychologists however would prefer to say that the two ideas form parts of a *system* which tends to be reinstated as a whole.

Again 'friend' may have suggested 'kindness' and we may say that it is a part of the *meaning* of friend, and so again the whole system or complex concept comes to mind, Or it may be that the idea of kindness occurs through the

functioning of an idea of relationship—that of 'quality,' even if the thought of that relationship is not in mind.[1]

With a series of odd words such as those given for the experiment the student will probably be struck by the great influence of the factors of frequency and recency. It would be interesting to compare the results of Experiment III. with those gained in the following experiment.

Experiment in Continuous Series of Associations. —Write a list of thirty words as quickly as you can, starting with the word *town*. Write down whatever comes into your head. It is especially interesting if a group of people perform this experiment together and afterwards compare lists. The factor of dominant interest has a better opportunity of showing itself in a continuous list of this nature and often betrays marked individual differences between the persons taking part.

In *continuous thinking* the associations are more completely determined by the interest and purpose of the moment than by such factors as recency and frequency. Yet underlying this will be the influence of the other factors. In the case of the successful thinker, irrelevant ideas—stray associations due to recency or frequency, but of little value for his present purpose—do not frequently occur. In the case of the genuine orator appropriate ideas flood his mind, the interest and purpose of the moment dominate all his thoughts. With the slovenly inefficient thinker, on the other hand, the first three factors mentioned are not adequately controlled by the interest and purpose of the moment. Hence the irritating irrelevances frequently introduced.

[1] Similar mental processes will be studied later in Expt. XLII., on Associations' Restricted and Guided by Relationships.

Educational Significance of Experiment III.—This experiment has been given chiefly as an exercise in self-observation and as a means of studying concrete cases of the workings of these conditions determining associations, rather than because of any direct bearing of the experiment upon matters of educational interest. Yet we may consider the comparative importance of the first three factors in the processes of learning.

Recency is the factor upon which the crammer relies to ensure recall, and it is obviously the least valuable from the teacher's point of view, as it gives no guarantee of permanent retention.

Intensity of Interest is the factor of which, above all, the teacher should seek to make use in fixing an association. The more intensely interesting an idea is made, the longer it will be retained and the more readily it will recur. It should be noted that there is a tendency for the *first* impression of anything, or the first occurrence of an idea in connection with another, to be especially interesting and lasting, because of the element of novelty, a fact which makes it all the more important that such first impressions or associations should be correct. Thus one disadvantage of a child's trying to guess say the meaning or spelling of a new word is that it may set up a wrong association with the word which may continue even when the teacher's correction has been forgotten.

A poor substitute for the factor of Intensity of Interest, but sometimes perhaps a necessary one, is that of Frequency—used when we seek to fix an association by constant repetition.

Experiment IV.

Unconscious Influences in Association.—The purpose of this experiment is to introduce the student to the

study of the influence of the "unconscious" or "subconscious" on thought and mental life generally. When the experiment is completed the student should make a careful study of all his own "reaction words" and of the length of reaction times. Note especially any prolonged reactions. Let your mind dwell upon the two words and note what associations are called up. Do the same in reference to cases in which the stimulus word was merely repeated or seemed to give a "blank" followed by such a statement as "nothing came." Consider also any cases in which the association seems unusual and inexplicable. Each student should study his own reactions; it is not intended that he should pry into the secret places of his partner's mind.

In some cases there may be a reason for a delayed reaction which is obvious to the subject. He wishes to avoid speaking the first word suggested by the stimulus word and hence rejects it for another, and so delays the reaction. In such cases the delay may be of no special consequence for the special purpose of this experiment which is concerned with the influence of forgotten or half forgotten experiences on mental life, or the influence of emotional elements at least temporarily out of consciousness and yet at work.

In some persons this test reveals nothing of special interest. In most, however, one or two delayed associations lead back to some experience, usually of an emotional type, which was not thought of at the time of the experiment: which even may have been almost completely forgotten for many years, but which seems likely to be the cause of the slight disturbance of the mind in the experiment, and which may be of some unsuspected influence in other ways in the life of the subject. In some cases unpleasant memories are revived thus which have been

more or less repressed, and it is possible for the subject by readjusting his attitude towards them in the light of new experiences, to lessen the influence of such "complexes," the name given to an idea or a group of ideas and the associated feelings which have been repressed and, which consequently have an undue influence on the mind, leading to irrational conduct or feeling.

It is impossible here to discuss the "new psychology of the unconscious."[1] But exaggerated as are many of the statements made as to the revolution in psychology caused by psycho-analysis there is little doubt that it has influenced psychology permanently. And it is well that the teacher should study something of it, partly because of its suggestiveness in many parts of his work, and partly to be on his guard against the exaggerated statements of extremists, and the uncritical advocacy of freedom from all dicipline, based upon them.

The list given in Experiment IV. is largely based on that used by Jung, and it includes a number of words which have been inserted specially to strike the most common types of complexes.[2]

In interpreting the results of the experiment we must bear in mind one important fact which is often ignored by psycho-analysts. As we saw in Experiment III. "the general trend of mental activity at the time" may dominate the process of recall. Thus if the subject thinks that the

[1] In a book entitled *The New Psychology of the Unconscious* I have attempted to give a critical introduction to the study of psycho-analysis and a brief account of the relation of the "new" psychology to older psychology, and of its significance for teacher and parent. References for further reading on this topic are also given there.

[2] Jung's full list is given in his *Analytic Psychology*, Chapter II., where he also discusses the use of this method.

experimenter is on the look-out for delayed reactions due to sex repressions (adopting Freudian views) *or* to unsatisfied self-assertion (following Adler) the idea is sure[e] to influence the line of association and so manufacture the very evidence the psycho-analyst is looking for.

If such theories were known before this experiment was done the student should look for their influence. If not a second test may be done with a new set of words and with these theories in mind, to see the result.

Speed of Reproduction of Ideas as a Test of Intelligence.—A rough test of intelligence and of one aspect of the mental alertness of a child may be made by getting him to say as many words as possible (not in sentences) in three minutes, Professor Burt indeed says that "No test so impressively displays the dullard's mental poverty and alertness." He shows it not only by the paucity of words but by lack of topical continuity.[1]

[1] See his book *The Backward Child*, pp. 488 and 493. The value of such association tests is admirably set forth in these and adjoining pages.

CHAPTER III.

ATTENTION.

Experiment V A.

Concentration of Attention.—The first purpose of this experiment is to bring home to the student how very difficult it is, even for an adult (and still more for a child), to keep the attention fixed upon the same object for more than a very few moments. On the average there tend to be four or five fluctuations of the attention in the minute in Test A, some people having as many as ten or twelve, though a few manage to avoid any fluctuations for as long as a minute. In these last cases, however, the subject has generally followed the method of Test B to some extent, *i.e.* he has thought things *about* the figure. In Test A these should really be reckoned as fluctuations. This setting oneself new questions about the figure makes an enormous difference to the possibility of concentrating the attention. Half of one class of sixteen students reduced their fluctuations of attention to 0 in Test B, the total number of fluctuations for the whole class being 46 in Test A and 19 in Test B.

What is the significance of this? It indicates the craving of the human mind for change. The man who constantly repeats the same idea bores us; the one who is continually seeing and suggesting new points of view and new questions even upon threadbare topics stimulates our interest and attention and is voted an interesting man. In these two opposite cases we have further examples of

the effects of the law of attention illustrated by the experiment.

The mind is ever seeking some change, and cannot even with an effort keep the same idea before itself continuously. Thus, if the teacher wishes to hold the attention of the children to one object or central idea for a long period, he can only do so by suggesting new points of view, and new questions about it. Thus can the mind be led to play about the same central topic for some time.[1]

EXPERIMENT V. B.

The Fluctuation of Attention.—Experiment V. B. gives an example of fluctuation of attention on a perceptual level. It further illustrates the power of volitional attention in almost excluding at times one figure by an effort to attend to the other. Even if this is brought about partly through a change in eye focus, it is remarkable. Note also the help gained in the concentration on one figure, by counting the lines, comparing the spaces, etc.

EXPERIMENT VI.

The Control of Attention.—Experiment VI. illustrates the rule that in order to keep any given idea, X, out of the mind it is best to supply the mind with a new and attractive idea, Y, to take its place. A merely negative attitude is insufficient. The mind insists upon some object of thought in reference to which it can be active. One subject, by having a positive idea on which to concentrate, reduced the number of times his mind wandered to the "forbidden" topic from 8 to 2, another from 21 to 11. Many subjects have fewer fluctuations of attention to the forbidden topic than the numbers mentioned. But

[1] On this topic and Experiment V. B. see James, *Principles of Psychology*, Vol. I., p 420.

unpractised subjects, in this experiment as in the preceding one, are apt to pass by a few fluctuations of attention without giving the prescribed sign. For a class of beginners in Experimental Psychology, twenty in number, the total number of observed movements of attention to the forbidden topic was as follows: during the first minute, 64; during the second minute, with the aid of an idea upon which to concentrate, 30.

In doing the experiment the subject would realise how the very suggestion that he should not think of the holidays led him to do so. Teachers will thus see the inadvisability of merely telling children *not* to attend to this or that. Rather should they seek to emphasise the idea which should take the place of the thought of the forbidden object. Not only will this be more likely to be effective with the child whose mind is wandering to some forbidden topic, including external objects of attraction, but the teacher will thus avoid suggesting any such topic to the other children.

Experiment VII.

The Division of Attention.[1]—It would obviously be a very valuable capacity if we could attend to several things at once. Some people do appear to have a special "gift" for keeping a number of things in mind at the same time, while every teacher is familiar with the child who seems incapable of holding in mind two items of instruction at once. The child may, for example, remember to march properly, but in that case he does not hold up his head, or if he succeeds for a time in holding his head properly, he straightway forgets about the marching.

Psychologists have questioned whether it is ever possible

[1] See also James, *Principles of Psychology*, Vol. I., p. 405.

to attend to two distinct mental operations at once. Experiment VII. is intended to bring out clearly some facts bearing on this problem.

In Experiment VII., if the subject were quite able to do the two things, counting and writing letters, at once, without one interfering in any way with the other, then in the combined Test C he should score as many figures as he counted in Test A, and as many letters as he wrote in Test B, for he had the same length of time, viz. one minute. That he should do this is, of course, very unlikely. If, on the other hand, the subject were never able to attend to both operations simultaneously at any moment during Test C, his score for counting is likely to be no more than half what it was in Test A, and his score for writing letters will be only half what it was in Test B.

For example suppose in Test A he counted 60 odd numbers and in Test B wrote down 40 letters; now if in the combined test he scores exactly half these numbers (30 odd numbers counted and 20 letters written), this may mean that his attention has simply been fluctuating from one thing to the other and on no occasion has he been attending to both operations at once. This is assuming that during Test C he divides his attention equally between the counting and the writing. Probably, however, the subject will find that he has neglected one and favoured the other. In most cases there seems to be a tendency to favour the writing at the expense of the counting, probably owing to the fact that the paper and the previously written letters are there before his eyes and help to hold his attention.

If, however, in the combined test the subject scores more than 30 numbers without lessening proportionately his sum of 20 in letters (or if he scores more than 20 letters without lessening proportionately his score of 30

numbers), this suggests that at some moments he has been doing both things at once.

Some subjects are evidently able to do this. But it does not seem to be because the attention is split between the two operations. It appears rather that one operation, say writing the letters, is started with attention concentrated upon it, and then while the subject is writing A, B, the attention takes in at a glance, so to speak, three or four following letters; he then continues to write the letters C, D, E, F mechanically while his attention turns to the counting. Thus what may appear at first sight to be a division of attention may be one of two things:—

(1) a very rapid fluctuation of attention from one thing to the other;

(2) a partial "mechanisation" of one of the two operations.

All this does not contradict the statement with which we started, viz. that some people are much better able than others to do two things at once. We see, however, that probably what they do is to reduce one of the two operations to a habit, at least to a kind of temporary habit. This power of mechanisation is itself valuable and is possibly one element in what we call "general intelligence." Some mental defectives seem especially weak in this respect.

In Experiment VII. I have found some subjects so flustered by the attempt to do two things at once that they actually do worse in *both* operations than they would have done if they had given half of the time to each. It may be of interest to the teacher to find out which of his pupils are best able to do the combined test, and to note whether those who do best in the test are those who show most alertness in the ordinary school work.

Individuals vary in the kinds of things which they are able to reduce to a mechanical habit. Thus child A may

learn to count mechanically more rapidly than child B, yet child B may more easily mechanise certain drill movements, thus leaving the attention free to attend to and learn more complicated movements.

In Experiment VII. the subject was told to count odd numbers, instead of every number, expressly for the purpose of making the counting less mechanical. If the subject tries the experiment again, counting every number—1, 2, 3, etc.—this time, he will realise how much more attention he can now give to the writing work.

Experiment VIIIa.

The Attraction of Attention.—Suppose a list of words is read out to a group of about twenty people and they are asked to write down all they can remember. If we then count how many people have written down the first word, how many the second, how many the third, and so on, we generally get a list somewhat as follows :—

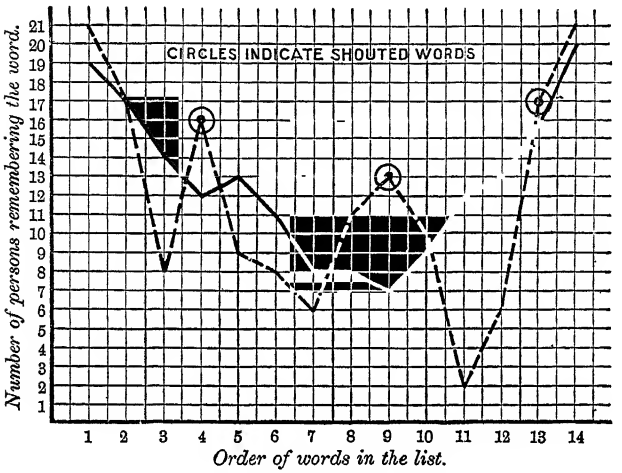
Order of word in the list	1 2 3 4 5 6 7 8 9 10 11 12 13 14
Number of persons who remembered the given word	18 17 14 15 13 11 8 8 9 12 15 15 18 20

This gives us a curve as in Fig. 9 (plain line), the special characteristic being the great "sag" in the middle. The nature of this average curve is due to several causes, the most important being the fact that the words just heard at the end are naturally recalled at once and written down while fresh in memory, while on the other hand the first word or two on the list receive complete and undivided attention when they are heard.

When, however, certain words are emphasised (as in

Experiment VIII. A by being pronounced much louder than the others, their score is considerably increased and the curve is modified in a way indicated by the dotted lines in the curve below. This is the graph of an actual experiment with the given words of Experiment VIII A.

CURVE SHOWING MEMORY OF A LIST OF WORDS.



Plain line—average curve when words are read out in an ordinary voice

Dotted line—actual curve of an experiment: points with circles round them indicate scores of words which were shouted.

Fig. 9.

Even if the loud-spoken words do not score more than all of the other words[1] (as indeed they are quite likely to do), they tend to score much more than is usual *for words in their position*; hence the value of a normal curve with which to compare the curve of the scores of Experiment VIII.

[1] With the exception of the first and last.

Now it may be thought that the high scores of the loud-spoken words are due simply to their loudness. It is indeed true that attention is attracted by the more intense stimuli, other things being equal; but that this is probably not the sole cause of the greater score of these words will be shown by Test B of the same experiment. Here the *whispered* words tend to be remembered better than the other words —or at least better than is normally the case with words in their position in such a list. Thus in a class experiment the average score of the whispered words was 13, that of the other words (excluding the first and last) only 9. Yet in the case of the whispered words the stimulus is actually *less* intense, so that the factor or "law" of intensity is working against them.[1] The fact is that in both experiments *attention is attracted by the sudden change* either to whispering or shouting, and, in accordance with a well-known psychological law, that which is attended to most completely is best remembered.

The plotting of such curves is, of course, only possible where the experiment is done by a group of students. If the reader simply does the experiment upon one subject he may get some estimate of the effect of this law as follows. The first and last words of both lists (Tests A and B) should be ignored as being especially liable to be remembered owing to their positions. This leaves in each list twelve words—nine read in an ordinary voice and three shouted or whispered; adding the lists, we get eighteen ordinary words and six "change" words. The reader can now calculate what proportions of each of these classes were remembered by his subject.

[1] Thus even if, as sometimes happens, the whispered words only retain a normal position in an average curve, this means that they have somehow made up for the loss of intensity of stimulus. This itself is evidence that some other factor is at work.

This experiment illustrates the law of the attraction of attention by a change from a somewhat different point of view from that of Experiment V. There we were concerned with volitional attention, here we are concerned with a more passive aspect of attention.[1] From this point of view the law can be applied to the manner as well as to the matter of teaching. It is the psychological justification for the use of variation of tone and gesture in order to hold the attention, as well as for the introduction of some variety and novelty in material.[2]

Experiment VIII. B.

The Distraction of Attention.—The effects of distracting stimuli on continuous attention are very varied. The subject may soon become accustomed to a regular interruption: it may even prove a stimulus to greater concentration. Work is more apt to be disturbed when the disturbance is irregular, and when it appeals to the same sense as that required for the work in hand, *e.g.* if noises break in when one is trying to attend to words being read out. The student should also compare the results when the work is mechanical (as in marking selected letters) with results when the work involves more

[1] There is still, of course, volitional attention, but the shouting or whispering forces some words upon the attention, and so an element of passivity is introduced.

[2] My colleague Mr. A. P. Braddock, when doing this experiment with a large class of about ninety students, found a marked tendency for the word *immediately preceding* the stressed word to score below the other unstressed words; hence he makes the interesting suggestion that the experiment also illustrates the influence of retro-active inhibition.

thought—as in crossing out all the nouns in a passage, or in the multiplication test.[1]

Experiments on the distraction of attention are entertaining to children, and, as Burt remarks, prove convenient means of watching the process of attention and of indicating the child's power of application—though this itself of course will vary with the degree of interest in the main task. Burt found it a useful test with backward children, though the *quantitative* results were of little value.[2]

[1] Typical results gained in experiments on the distraction of attention are summarised in *A Textbook of Experimental Psychology*, by C. S. Myers and F. C. Bartlett (see the chapter on Attention), and more fully in *General Experimental Psychology*, by A. G. Bills, Chap. 25 (New York, 1935).

[2] See *The Backward Child*, p. 484.

CHAPTER IV.

ECONOMICAL METHODS OF LEARNING.

Experiments IX. and X.

Individuals vary greatly, but most readers will probably be surprised at the extent to which the "whole" method of learning succeeded with the poetry, unless they found the pieces hard to understand. In experiments of my own, using the given pieces, about two-thirds of the students found the "whole" method superior, the superiority being especially marked when the students wrote out what they remembered of the poems a week after they had learned them. It would be well for the reader to add this additional test, for it is in prolonged memory that the "whole" method has generally been found to show its superiority most markedly. It should be noted also that practice in the use of the "whole" method reveals its superiority still further.

At the same time I have found some students who seem to find the sectional method the better. The various characteristics which seem to make the "whole" method usually superior do not seem to affect all equally. In general, previous experimenters seem to assert more unreservedly the superiority of the "whole" method than I have done above. One investigator found the superiority of the "whole" method much greater when he used poems considerably longer than those given for use in the present

experiment, extending even to 240 lines. But probably many persons would get discouraged in attempting to learn such long poems by the "whole" method. They would feel they were making no progress.

The Advantages of the Respective Methods.—Let us consider the various points involved in the respective methods when applied to poetry or continuous prose. In the sectional method there is obviously a danger of leaving weak points between the sections, even if the sections as such are well known. Hence the frequency with which children forget the beginning of "the next verse" even though they are able to finish each verse when told the first word or two.

In the repeated reading of one section the mind passes from the end of the section back to the beginning of the same section, instead of to the beginning of the next section, as is required. Thus there is a possibility of wasted energy and of wrong associations. With the "whole" method there is no such waste. Further, the general meaning of the poem is better kept in mind by the "whole" method.

On the other hand, as one reaches a stage at which nearly all the lines are known it certainly appears waste of time to go over the whole poem in order to strengthen the few weak spots. But this added repetition will tell when the attempt is made to recall the poem after a considerable lapse of time. Thus it is not surprising that the superiority of the "whole" method has been shown to be more marked when the memory of the poem is tested after some days or weeks.

The nature of the material to be learnt will obviously affect the comparative values of the two methods. The less the poem forms a unity, the less it is dominated by

one or two leading ideas, the less will be the comparative efficiency of the "whole" method. In such material as a long vocabulary, say of English and foreign words, there is of course no such unity. And in such a case, further, it is the "whole" method that leads to useless and even injurious associations. Thus, supposing I am learning the following list of words and their meaning:—

Sitte	Custom
Reiz	Stimulus
Aufmerksamkeit	Attention

Now if I read the list rapidly thus—*Sitte* . . . Custom . . . *Reiz* . . . Stimulus . . . *Aufmerksamkeit*, I may tend to set up the useless associations Custom–*Reiz*, and Stimulus –*Aufmerksamkeit*, and this is not only waste of time and energy but it may mislead me into giving *Reiz* as the German for "Custom."

Those who learn lists of vocabularies often find that while they know a word in its appropriate place in the list, they fail to recognise it alone. The supplementary associations with the other words in the list in which it was learned are necessary for its recall. This is especially the case if the list is read through as a whole.

Further, when the material to be learned is a vocabulary, the sectional method has not the disadvantage it has when a poem has to be learned; in passing backwards from Attention to *Aufmerksamkeit*, and then again to Attention and then back to *Aufmerksamkeit*, I am not setting up a useless association as I was in passing from the end of the first section of poem A back to the beginning of the same section. Indeed it is just as useful for me to pass from Attention to *Aufmerksamkeit* as vice versa. Otherwise I am likely to find that while I can give the English for *Aufmerksamkeit* I cannot give the German for Attention.

Yet, in spite of these facts, I have found the "whole" method scarcely less efficient, on the average, than the sectional method even in the learning of vocabularies. The repetition of the same two words several times over tends to become very uninteresting, and leads, with some subjects, to a mechanical kind of attitude, whereas the passing constantly from one word to a new one keeps the attention alert and vigorous. Also some subjects are better able than others to attend to the foreign word and its meaning as one whole, quite separate from the rest, and these subjects do not experience the tendency, of which we have just spoken, to associate the meaning of the first foreign word with the second foreign word (*e.g.* Custom–*Reiz*) even when they read the list straight down.

These and other variations lead to great diversity between individuals. Each student must find out the method which suits him best, observing as far as possible the reasons why that particular method suits him. This applies both to learning vocabularies and to the learning of poetry or connected prose

As regards poetry and prose we may say, summing up, that for most people the best method of learning a piece of poetry or prose is to read the whole repeatedly, except perhaps that when the piece is almost known specially difficult sections may be selected for additional learning.

The Influence of Interest and of Age.—As in all learning, interest is an important factor in determining the ease or difficulty of the learning and the retention of a poem: and in any experiment with an individual learner this may be far more important than the method used.[1] Hence the stress laid upon the importance of choosing poems of equal difficulty.

[1] See C. Fox, "The Influence of Subjective Preference on Memory," *Brit. Journ. of Psych.*, Vol. XIII

In the group experiment suggested (p. 23) it is arranged that each poem shall be learned by the whole method by half the class, and by the sectional method by the other half. Thus, if numbers are adequate, it becomes highly improbable that special interest will favour either method.

The values of the respective methods vary according (i) to the age, (ii) to the ability of the learner, and (iii) to the degree of unity of thought in the poem.

Very young or very dull pupils are less able to grasp the general unity of thought, and they need more the encouragement of feeling that part of the work is done. On the other hand certain experiments which suggest that the whole method is no better for children of twelve[1] are vitiated by the fact that the tests did not give time for all the poem to be learned, and this would favour the part method. A more recent enquiry by one of my research students suggests that for pupils of good intelligence and with poems comprehensible to the pupils, the whole method is superior even for eleven or twelve year old pupils.[2]

[1] See W. H. Winch, "Should Poems be learned by School Children as Wholes or in Parts?" *Brit. Journ. of Psych.*, Vol. XV.

[2] See E. W. Sawdon, "Should Children learn Poems in Wholes or in Parts?" *Forum of Education*, Vol. V., 1927.

CHAPTER V.

MENTAL TYPES AS REVEALED BY ASSOCIATIONS AND DESCRIPTIONS.

Experiments XI., XII. and XIII.

These experiments are based upon tests performed by a distinguished French psychologist, the late Professor Binet, upon his two daughters, Armande (age 13 years) and Marguerite (age 14½ years). Binet found that very striking mental differences between the two girls were revealed by these and other tests. Indeed each girl might be said to belong to a fairly marked type. Briefly we may say that Armande was "imaginative" and Marguerite "matter-of fact."[1] We will discuss their results in detail and this will give the reader the clue as to the method of grouping and classifying both his own results and those of any children on whom he may care to repeat the tests.

Experiment XI.

Classification of the Lists of Words Written.—Binet had sixteen lists (of 20 words each) written on different occasions. I have not troubled the student with so many lists, as the main point for him is to grasp the principle involved. But in applying the test to school children it would be well to get as many lists as possible

[1] This is only a rough summary. As we shall see, in some very desirable qualities Marguerite surpassed her sister.

done on different days, to avoid any particular mood or train of thought dominating all the lists.

In experimenting Binet took his daughters separately, and after each list of words was written he questioned them closely as to what exactly they had in mind when each word occurred to them. He then classified the words under the following heads. (Binet himself asserts that the classification makes no pretence at being a scientific one.)

1. *Unexplained words, i.e.* words in reference to which the child could not say what she had in mind when she wrote the word down. She only knew that she thought of the word.

2. Words referring to *objects present* at the time of the experiments, *e.g.* the table on which the child was writing, a picture in the room, the sky visible through the window.

3. Words *connected with the subject herself*, or her personal belongings, *e.g.* her hair or her clothes.

4. *Definite memories.* Here the words were thought of as referring to past experiences which were definitely recalled. These were further divided into old or recent memories, according as they were more or less than three months old.

5. *Abstract and general terms*, including not only abstract terms proper, such as "courage," "goodness," "redness," but also names of classes, such as "house" or "children."

6. *Definite imaginations.* Here some definite object or experience is thought of, but it is not a memory of a past experience. Nor is it merely a general idea such as "houses" or "children": it is the thought of some definite yet imaginary house, or of definite but purely imaginary children. It is sometimes difficult to decide whether a word is to be classified as general or imaginative. Doubtful cases may perhaps be counted as ½ to each, unless they are so indefinite as to go under Group 1, Unexplained Words. It should be noted that an imagination-thought may accom-

pany an abstract word. Thus one girl wrote "sadness" but thought of an imaginary person in trouble: this was accordingly put into Group 6.

The following table summarises the results of Binet's experiments.

	Armande.	*Marguerite.*
1. Unexplained words.	Frequent—about one word in three. Also, they were often very uncommon words.	Much rarer than with Armande, only about one word in twenty; and usually commonplace words.
2. Present objects.	Only 30 words out of 320.	Four times as frequent as with Armande.
3. Names of things of personal interest to the subject.	Very rare.	Fairly frequent.
4. Memories.	Old memories predominate.	Recent memories predominate.
5. Abstract and General Terms.	Six times as many as Marguerite.	Only 12.
6. Imaginations.	23.	None.

Let us consider the significance of these differences.

(1) *Unexplained words.*

Armande forgot the exact significance of far more words in her list than did Marguerite. This may have been due to various causes—(*a*) The rapidity of writing, (*b*) Loss of memory, (*c*) A state of distraction, (*d*) A tendency to "verbalism," (*e*) Lack of precision.

Binet noticed that Armande wrote considerably faster than did Marguerite. In order to see whether this was the reason why Armande had so many "unexplained" words he gave the two children several tests of a similar kind, but

on these occasions he asked them to write down the words as fast as they could. In these new tests Marguerite wrote down words as quickly as Armande. Yet the mental type still showed itself: Marguerite now gave about 35 per cent. of unexplained words instead of 5 per cent. previously; Armande now gave 80 per cent. of unexplained words instead of 28 per cent. previously.

It will be seen that the hastening of the speed does lead to a greater number of unexplained words in both cases. Yet the marked difference between the two girls remains even when they work at the same (maximum) speed. Thus speed of writing cannot explain Armande's excess of unexplained words. Binet found later that Armande had a weaker memory than Marguerite for a number of kinds of things and this may partly explain the difference under Group 1. But it also possibly indicates a proneness to distraction on the part of Armande, a certain vagueness in her way of thinking, and a tendency to verbalism, *i.e.* merely thinking of a word as such, with no thought of its meaning.

(2) *Present Objects.*

Why does one subject write down in her list so many more names of objects present to the senses at the moment than is the case with another subject? There are at least two possible causes for this. One is a general poverty of ideas. The subject then tends to look about her to find something to write down. Another explanation may be that the subject lives more in externals and less frequently loses mental contact with the material world about her. This seems to have been characteristic of Marguerite, while the attention of Armande was more naturally drawn inwards, though not, be it observed, towards herself particularly.

(3) *Things of Personal Interest* to the subject.

Marguerite had about four times as many words

of this class as Armande had. Binet remarks that this exactly fitted in with his general observations of his daughters, Marguerite being much more attached to her own possessions and regretting their loss or injury more than was the case with Armande.

In this respect it appears that Marguerite was normal while Armande was unusual, for Binet also performed some similar tests upon a number of school children and found that nearly all of them gave in their lists a large number of names of objects belonging to themselves.

(4) *Memories.*

Of recent memories Marguerite had 139, Armande only 30. Of ancient memories Marguerite had 33, Armande 58. It has been suggested that these results also are connected with Marguerite's greater attachment to the visible world, but further analysis of the results would be necessary before this conclusion could be made.

Binet observed that the school children whom he tested included in their lists more memories having reference to school instruction and learning than was the case with his own daughters. Doubtless the fact that he was their father and that the experiments were done in their own home would influence the general set of their minds. The experimenter must always be on the look out for any such influences and the possibilities of suggestion.

Binet noticed that his daughters made no use of recollections of school lessons in ordinary conversations. This fact, and the fact that such recollections did not spontaneously occur in the word lists, indicate a lack of thorough assimilation of the school learning, a fact highly suggestive to the teacher.

(5) *Abstract and General Terms.*

Binet remarks that, while he knew Armande to be imaginative, he was surprised that she had so many abstract

or general terms, thinking for example "house" in general without a thought of any definite house.

He raises the question whether this was due to laziness of thought, a failure to penetrate to the bottom of ideas and to think them clearly. He concludes, however, that it was not so, but that the size of this group in Armande's case was really indicative partly of a tendency to abstraction, and partly of a tendency to verbalism. As we have already seen, Armande was also suspected of verbalism on the ground of her excess of unexplained words.

(6) *Imaginations.*

Binet calls attention to the fact that Armande had more abstractions and yet more imaginations also than Marguerite. Now there is usually thought to be an antithesis between imagination and abstraction. Imagination is characteristic of the poet, the artist, and in a sense possibly of women and children more than of men; while abstraction is said to be characteristic of the theorist, the scientist, and the philosopher, who are interested in unities, generalities and laws.

But, as Binet remarks, Armande's abstractions were not abstract *reasonings*. They (more especially the general terms) were rather due to lack of definiteness than to a definite act of abstraction. Thus they afford no evidence against the above mentioned popular belief.

Inferences as to Mental Types from the Word Lists.—To sum up, these word lists suggest that the two sisters are of very *different mental types*. Marguerite is interested in the world around her, with ideas comparatively slow in development, yet more definite and precise, and better remembered than those of Armande. She is practical and "objective," attached to the things in her immediate vicinity both as regards place and time.

Armande, on the other hand, is characterised by a rapid flow of ideas, sometimes, however, merely by a flow of words without very definite ideas attached to them (verbalism); these more fleeting ideas are more readily forgotten, and their very wealth is perhaps partly the cause of the lesser extent to which she observes the external world about. Her thoughts are further removed than Marguerite's from the present, both as regards space and time, and with this lesser dependence on and interest in the visible world there are more imaginings, at least of certain kinds.

The student should now classify his own words and note the extent to which he approximates to one type or the other. If he has done all his lists on the same day he must not be surprised if they are somewhat lacking in variety.

It must not be supposed that most persons belong to one or other of these two types. No doubt Armande and Marguerite were extremes, and most children and adults will be more "mixed." Binet was fortunate as an experimenter in the fact that his daughters differed so widely, otherwise his book would not have been the intensely interesting work that it is.

Experiment XII.

We shall see how the broad distinctions already observed between Marguerite and Armande appear again in Experiments XII. and XIII. Here are some of the sentences completed by the two girls:—

Armande.	*Marguerite.*
"*I am hastening* to write to you, for I have scarcely any longer to live." (Age 13!)	"*I am hastening* to finish my tasks in order to have time to play afterwards." (Doubtless a statement of fact.)

Armande.	*Marguerite.*
"*The house* is on a height whence one sees a precipice, then a town of which one hears feebly the dull and distant noise."	"*The house* is warmed by a good hot-air stove" (a true fact concerning the house in which she was writing).

Similarly one of my students wrote: "*I am now* an old man" (she was a young lady of some twenty summers!), while many wrote, quite truthfully, "*I am now* doing psychological experiments."

The student will not find it difficult to distinguish between the imaginative and the "matter-of-fact" completions in this test.

Experiment XIII.

Descriptive Types.—The characteristic difference between Armande and Marguerite appeared again in this experiment.

Here are rough translations of the *descriptions of an old halfpenny* by Marguerite and Armande.

Marguerite's description.—"The piece of money I have before me is a sou: it is made of copper, stained through long usage. The back of this piece represents an eagle with wings spread out, for it dates from the Emperor Napoleon III. On the back is written: 'Empire Français, 5 centimes.'

"On the front is the head of Napoleon III. surrounded by the words 'Napoléon Empereur,' and below is the date when the piece was struck, but it is too much effaced and I cannot read it. This piece is not thick—about 2 millimetres."

As will be seen, this is almost purely descriptive, the work simply of a careful observer.

Armande's description.—This begins with some state-

ments of fact, as in Marguerite's case, and then comes an imaginative touch. "How much it would have to relate if it could speak, this sou. Whence has it come? in what lands has it been? One does not even think of it in seeing a humble sou, one does not seek its history, mon Dieu, no! It appears so simple to see, a sou. It is so common. Sous pass unperceived like so many things one is accustomed to see everywhere. . . ."

In this experiment Binet told his children to "describe" the halfpenny, etc I think it better to use the phrase "write a dozen lines about the halfpenny." This gives greater freedom and results are not so dependent upon the extent to which the subject literally obeys instructions.

Among students I have found more approximating to the Marguerite type than to the Armande type as judged by this test. I quote here, however, a striking example of the Armande type as shown in the description of a halfpenny. Of course the subject had not heard before of the characteristic differences of Marguerite and Armande in this respect.

A student's comments upon a halfpenny.—"This is a coin made of copper. On one side is stamped the head of the late king, on the other side the figure of Britannia. If the coin could speak it might tell many a wonderful story. It may have travelled the whole world over, it may have seen many a rich dwelling or many a poor hovel. It may have been dearly prized by a little child or thrown from a rich man's hand to a poor beggar. At present it lies here, the medium of the first experiment of a student."

These description tests have been used for a considerable number of school children and it has been found that, broadly, four types are distinguishable, though many are of a "mixed" type: and practically all will give some comments of each type.

Four Descriptive Types

(1) The Describer, who merely mentions all the obvious features of the object which has been given to him.

(2) The Observer or, perhaps better, Interpreter, who is somewhat reflective, drawing inferences perhaps from what he sees, *e.g.* a guess at the coin's date from the evidence of its worn appearance.

(3) The Imaginative, possibly not so accurate or complete in observation. The student's description of a halfpenny given above is a good example.

(4) The Erudite, who tells what he knows about things, making use of general information or of that gained in school; *e.g.* the statement that the halfpenny was made of bronze and that bronze is an alloy of copper and tin, and the giving of the reason why this alloy is used. This kind of answer may indicate an exceptional amount of information, but it may be partly due to an aversion to the careful and patient observation necessary to give one enough material to write about the appearance of the object.

The Use of Experiments XI., XII. and XIII. in School.—Experiments XII. and XIII. would be easy to give to a group of children. For Experiment XI. one may allow all the children together (of a *small* group) to write down their lists of words, but they must be questioned individually afterwards, for the words alone may be misleading, as we have seen. It would be much better, however, to take the children individually, as each should be questioned immediately after writing his list of words.

In forming his judgment as to his own type or that of any children whom he may test, the reader should of course take into account all the evidence gained from Experiments XI., XII. and XIII. The imaginative element, for example, may not appear in all the tests.

Finally, it must be emphasised that each 'type' shows some characteristics of the other types. Persons belong to a type only in the sense that they reveal a greater proportion of certain kinds of ideas than do most people.

The reader must also guard against the assumption that the Imaginative (Armande) type is necessarily superior to the Marguerite—what we may broadly call the Observer—type. The former is of course superior to the latter in certain kinds of "imagination." But the latter is strong in qualities which may be just as admirable and at least as useful, though possibly less interesting, namely—precision of thought and patient and careful observation.

The teacher might find it interesting to compare the results of these experiments with his pupils[1] essays.

The Study of Types—Intellectual and Temperamental—These experiments may also serve as a useful introduction to the whole study of mental types. Certain resemblances, for example, may be traced between the above 'Observer' (or 'Objective') type and 'Imaginative' (or 'Subjective') types on the one hand, and Jung's famous types—the Extravert (with interest or 'libido' turned outwards) and the Introvert (with interest or 'libido' turned inwards). It is indeed a good thing to approach the study of 'types' by the more intellectual material of ideas rather than by the study of the vaguer temperaments, as the complexity and intermingling of supposed types is realised more clearly, and so is the impossibility of fitting most people into any one type.[2]

[1] For a full account of Binet's numerous experiments upon his two daughters see his book *L'Etude expérimentale de l'intelligence.*

[2] On Introverts and Extraverts see Jung's *Collected Papers in Analytical Psychology*, Chap. XI., and his later *Psychological Types*. For a brief critical discussion see R. S. Woodworth, *Contemporary Schools of Psychology*, p. 184.

CHAPTER VI.

ROTE MEMORY.

Experiments XIV., XV., and XVI.

Visual and Auditory Tests.—One fact is made clear by class experiments on visual and auditory memory, viz. that it is possible to be good at remembering certain impressions (compared with other people) and yet at the same time be comparatively poor in remembering auditory impressions, or vice versa. The present writer, in his experimental classes, has frequently had students near the top of a class, of about eighty or a hundred students, in visual memory tests, but near the bottom in the auditory tests.

I do not suggest that there is no correlation between the orders in such visual and auditory tests. Indeed there is experimental evidence that there is some such correlation, but that it is not high.[1] It must be borne in mind that the orders of merit in our present experiment are based on only three tests each, and various accidents would tend to lesson the true correlation between them, which would appear larger if the tests were repeated several times with new materials. The difference, however, between the two orders is sufficient to illustrate clearly a fact which modern psychology is demonstrating more and more decidedly, namely, that it is inexact to speak of a person having

[1] In our own large classes it is usually no more than about 0·2, if that. (See p. 54 for an explanation of 'correlation.')

"a good memory" in general. It is well known that some people have a good memory for faces but a bad one for names. Experiments show that the remembering of words is a specific function. It is probably very rare that a person has "a good memory" even in the popular sense for everything—not only for visual and auditory impressions, but also for movements, touch, smell, taste, etc. These various capacities are, we find, to a very great extent independent of one another. Indeed we can go even further and say that a man may remember well certain kinds of visual impressions but less well some other visual impressions. Thus some students who did badly in the diagram test (Experiment XVI.) did fairly well in an experiment in which the memory for colours was tested, though this too was a visual test. Here the question of interest enters in. Thus we found a tendency for women to do better than men in the colour test, though not so well as the men, or at least no better, in the diagram test. No doubt this is partly due to the greater interest shown as a rule in colours by women than by men.

In all learning and recall indeed, special interest seems of greater importance than the particular sense concerned, especially in the learning of meaningful material; and most persons tend to read some meaning into at least a few of the diagrams and nonsense syllables.

Nevertheless, interest being equal, things seen are better retained, by some persons, than are things heard. Children of this type will learn their work in school most rapidly and easily when it is presented to them in visual form, while the auditory type will do better with material presented through the spoken word. The psychological justification for combining in a lesson both visual and auditory impressions wherever possible will thus be obvious.

Most persons seem to be of a mixed type, and the chief point to be considered in determining the mode of presentation is the material rather than the child.

At the same time it is well for each individual to know where his own particular strength lies, in order that he may know what means to use when exact memory work is urgently required.

In deciding the question as to his own type, the student may find some help in noticing the kind of mistakes that he makes. Thus persons who rely upon visual impressions tend, in such memory experiments, to confuse letters that look alike, *e.g.* C and G, O and Q. Persons of the auditory type, on the other hand, tend to confuse letters which sound alike, *e.g.* P and B, T and D, M and N.

Recognition and Recall.—Students may be interested to do a small supplementary experiment on the distinction between the degree of acquaintance needed for mere recognition and that for complete recall.

A set of twenty nonsense syllables is prepared. Ten, from among the twenty, are read to the class three times.

The students then write down all those remembered.

These are now covered up and the whole of the twenty syllables are then read out slowly, and students asked to write down each one recognised as it is read.

The greater ease of recognition is shown clearly in the following results obtained in successive years with my own classes.

Of sixty students—	Of seventy-five students—
1 scored more in recall.	0 scored more in recall.
5 scored the same in recall.	8 scored the same in recall.
54 scored more in recognition.	67 scored more in recognition.

In the first class thirteen students scored as many as 4, 5 or 6 more in recognition than in recall.

Imagery and Memory.—The relation of imagery to memorising is somewhat complicated. It is clear that a man *may* have vivid visual imagery and yet be weak in visual rote memory: *e.g.* in a class of 54, of seven students reporting visual imagery as "very vivid," four were 11th, 31st, 45th, and 50th respectively in rote visual memory tests, though the three others were 1st, 3rd, and 5th respectively.[1] On the other hand, it is quite evident that imagery may be used to good effect in both visual and auditory memory, though it does not seem to be essential. In another class five out of the first six in visual memory tests reported very vivid visual imagery, and one vivid; and they all report that visual imagery was freely used in the memory tests. Auditory imagery played a similar part among those at the top of the auditory memory list.

In visual memory work auditory imagery may be used and vice versa. Some students reported a conflict of imagery in the first test referred to above. The three high in visual memory had only "fair" or "moderate" auditory imagery, while those low in visual memory reported vivid or very vivid auditory imagery, and used auditory imagery much more freely than did the others in the memory tests. As one would expect, a number report the use of both

[1] F. C. Bartlett found a tendency for some strong visualisers to import a large amount of material into their accounts of pictures they had been shown, and also to be over-confident in these accounts. See his book, *Remembering: a Study in Experimental and Social Psychology* (Camb. Univ. Press). This book also shows with a wealth of detail and acute discussion, the influence of affective and other factors on the process of remembering. A most interesting discussion, by one who himself is a strong visualiser, of the functioning of images in remembering will be found in *Remembering and Forgetting*, by T. H. Pear. (Methuen).

types of imagery in learning the letters or nouns: auditory being used for the recall of the letter itself, visual for its position and arrangement. Possibly learning to use the most appropriate imagery with different types of material would be useful for the improvement of memorising.

In any case if a child is to visualise material presented through speech he must be able to construct the visual image, and this he is obviously better able to do, and do quickly (as is often essential), if he has had an appropriate visual presentation. This point bears upon the next experiment on the value of a map in which the student should note the extent to which he makes use of imagery.

Finally, it should be remembered that we have been considering an abstract aspect of memory work. Most memory work involves ideas with some logical sequence, and here the nature of the material seems usually to be of much greater influence than the mode of presentation.

Use of Experiments XIV., XV. and XVI. in School.—The various texts included under these experiments should not be difficult for the teacher to perform upon his pupils in groups. Of course he must allow more time for very young children to learn the material. By use of the tests he may be able to discover whether there are in his class any children either unusually strong or unusually deficient in either of these kinds of learning. He will probably find the children keenly interested in such tests and anxious to do their best, and he will thus get some light upon the capacities of children for rote learning.

The student may also test the effect of the lapse of time on memory. It has actually been found that children of six can do 50 per cent. better in the reproduction of a poem two days after the poem was learned than immediately after. The same is true, to a lesser extent, for older children. See P. B. Ballard, Obliviscence and Reminiscence, *Brit. Journ. of Psych. Supplements*, II.

CHAPTER VII.

ON THE VALUE OF A MAP.

Experiment XVII.

In this test we have an experiment bearing even more directly upon school work. It is one which I have used to bring home to students the great value of the support of visual impressions in learning and remembering material like that given in this experiment

Every teacher, one would suppose, knows the value of maps and plans,[1] but an experiment of this nature may bring home their value more vividly to the student and the exact points in which their help is especially useful, if he himself undergoes it, or if he performs the experiment on a class of children.

This experiment is really concerned with substance memory, but it is introduced here in order to illustrate the use of visual memory; it will further be seen that it involves a considerable amount of rote memory work in which visual impressions may be of service.

Most subjects will have realised the value of the map in doing the test, and will find that their performance in

[1] As a matter of fact, however, the present writer was led to devise this experiment after hearing of one teacher who, after a year's training, actually prepared and gave a geography lesson before an Inspector without a single reference to a map, though it was a lesson in which the use of a map would have been extremely serviceable.

Piece A is better than in Piece B, in spite of the fact that their going through Piece A will give them some hints as to the kind of questions to be prepared for in test B. For experiments with classes of students, the teacher can vary the experiment on other occasions by giving the auditory test first when once he has found what length of time is taken by test A. Obviously, if the values of the two methods are to be compared, the same length of time must be spent over each.

If the student doubts the equality of the two pieces as regards difficulty, he can easily make a sketch of Piece B and refrain from using the map for Piece A in a subsequent experiment upon another subject.

In a class of my own students, when Piece A was taken first with the map, and B later without map, the total marks for A were 25 per cent. better than those for B. In another class in which Piece A was taken first without the map and Piece B later with a map, the total marks for the "map piece," B, were over 40 per cent. better than those for A. The difference in these percentages is probably due to the clue given by the first test as to the kind of question to be asked after the second piece. In the case of the first class this advantage favoured the purely oral piece, in the case of the second class it favoured the map piece. The mean between the two, *i.e.* about 33 per cent., probably gives us a fair indication as to the superiority of the map method.

The extent to which various students have made use of visual imagery in this experiment should be noted.

CHAPTER VIII.

SUBSTANCE OR RATIONAL MEMORY AND THE CORRELATION BETWEEN ROTE AND RATIONAL MEMORY.

Experiments XVIII. and XIX.

Experiment XVIII. will have shown clearly the enormous difference made by the connection of the meaning of ideas to the possibility of memorising them. The obvious inference of practical value to the teacher is that, wherever possible, the ideas or facts which he wishes to impart in a lesson should form a connected series. One would think this observation unnecessary if one did not know how many teachers seem to rely almost entirely upon forceful repetition rather than upon reasoned connection.

Incidentally it would be noticed that the list of words connected in meaning was more interesting than the other list, and this greater interest of itself would aid the memory.

Experiment XIX.—The main purpose of Experiment XIX. is to demonstrate, when taken in connection with Experiments XIV., XV. and XVI. (rote memory), that it is possible for an individual to be comparatively good in remembering connected ideas and yet weak in rote memory tests or vice versa. Thus you may find, for example, that your partner has proved superior to you in rote

memory tests, but that you are better than he is in the substance memory tests.[1] This possibility, however, of a great difference between the two kinds of learning appears much more clearly if the experiment is done upon a whole class. The present writer has often had students who were at the top or very near the top of a class of twenty to thirty students in the rote memory tests, but near the bottom or actually last in rational memory tests. Of course learning by rote is of some value even in the recall of the prose passages, but so great is the help derived from connection of meaning by some individuals that they score better in a rational test even when competing with others who are much their superior in learning by rote.

We have observed that easy learning by rote may prove valuable in substance or logical memory work But in one sense the two kinds of learning are opposed and tend to discourage one another. Thus a man with a keen eye for the interconnection of things will look for such connections and tend to rely upon them in his memory work, while impressions which are not connected in meaning will tend to be neglected, partly from lack of interest. This means that his retention of logical material may improve at the expense of disconnected items. This is likely to be the case especially if most of his study is given to subjects which demand primarily reasoning rather than rote learning. There is, indeed, some evidence that even in a series of experiments concentration upon connected prose passages may produce a distaste for rote memory work.

[1] Of course such a difference may be due partly, or even entirely, to the different degree to which the test pieces appeal to the special interests and special knowledge of the individuals tested. It is almost impossible to avoid this complication altogether; one can however lessen its probable influence by increasing the number of pieces given and selecting a variety of topics.

Conversely, if a person is unusually good in learning by rote he may tend to rely upon this to the neglect of more reflective and rational work. Thus the lack of correlation between rote and rational learning is not so surprising as it might otherwise appear to be.

The Use of Experiment XIX. in Schools.—It would be a useful thing for a teacher to know as soon as possible the capacity of each of his pupils in learning and retention of various types of material, It would be worth while at any early stage in his first term with them to give some tests of this nature simply with a view to discovering the facts about each child. It is less reliable to depend for his evidence upon the general work of his pupils in any of the school subjects, as the order of proficiency in any such tests is determined by quite a large number of factors, *e.g.* the length of time spent in preparing the work and the previous knowledge of the subject.

Previous training and diligence are the very factors which the teacher wants to rule out in order to discover what the children *can* do in the way of memorising new material if they try and if they completely understand the matter. He should therefore select stories simple in language, but in which there is a rational connection between the successive ideas. The stories should deal with different topics, so that they will not appeal only to certain special interests. It would be wise to give one short passage each day for several days.[1]

In order that they may write freely, pupils should be told that no marks will be deducted for errors in spelling or grammar in these tests Ample time must also be given so that the slow writer is not handicapped.

[1] However varied the topics, we can never get quite rid of the influence of special interests and previous knowledge: and comprehension will always be of greater influence than mere retentivity.

As before, the statement to the class that he is going to "test their power of memory" will almost certainly secure, for the brief time necessary for the test, the keen attention of the pupils, especially if the teacher announces each day the results of the previous day's test. A comparison of the order of merit in substance tests and the order previously obtained in rote tests, will prove instructive, especially if both immediate and deferred tests are given.

Experiment XX.

Variations in Repeated Reproductions.—Some of the most interesting points which usually emerge in such repeated reproductions are these:—(i) the tendency of the main form of the *first* reproduction to continue; (ii) the tendency for details to become stereotyped; (iii) some individuals may elaborate the given material; (iv) recall of details is greatly influenced by the individual's special interests; (v) where the material contains an apparently irrelevant detail or the logical connection of some elements is not seen, the subject tends to 'rationalise,' linking details together, or changing some or introducing new ideas.[1]

Experiment XXI.

Group Serial Reproduction.—Some of the tendencies shown in the last experiment also reveal themselves in this. In one of my groups, with which procedure C was followed, the last reproduction was as follows:

A young man found a body in a station. Beside it stood a swarthy young woman. She took a newspaper cutting from her handbag, which contained an account of Fascism. Two Fascists were arrested in a London office in connection with crime.

[1] This experiment and the next one are based on one described in Professor F. C. Bartlett's book, *Remembering* (Camb. Univ. Press).

The 'body' had been introduced as early in the group as student No. 3.

With procedure A, in a group of six students, the account given by No. 6 was as follows:

"I read in a daily paper that a foreigner had been arrested. In his pocket was found a photograph of a beautiful girl. The man was an Italian. The same day two Germans were arrested."

With a longer folklore story and longer intervals in between the reading and a group of ten people Professor Bartlett got even greater changes. These showed specially a tendency towards variation—the omission of details which did *not* fit in with the main idea and the introduction of others which *did*[1]

In the above story I deliberately introduced the word Belgian—as not fitting in with the idea of spying in England, and the word was omitted in almost all the groups, some fifteen, with which I have done this experiment.

Oral Reproduction.—When the story (with the last sentence omitted) was passed round another group of twelve students by word of mouth, it ended as a statement about a railway train and a porter and his wife getting into it! The word 'Reporter' had evidently been misheard as 'Porter'—and the husband and wife suggested by the original story were merely linked up with the train in a likely way, for which however there was absolutely no basis in the story.

In another group of only four (including two children aged 16 and 12), the story became: "There was a reporter who went into an hotel and saw a beautiful woman who was a spy, but he found a paper that proved she was not one."

[1] *Op. cit.* p. 125.

While this experiment is perhaps of chief interest as indicating how reports and rumours change and grow, it is suggestive also for the teachers as to the tricks memory can play. Oral lessons especially are apt similarly to be moulded into a scheme fitting in with the bearer's preconceived ideas. It is notable that when Bartlett used an argumentative passage about a biological question, "the Modification of Species," he found the main statement absolutely reversed by the end of the series and new facts introduced.[1]

[1] *Op. cit.* p 168.

CHAPTER IX.

CORRELATIONS BETWEEN TWO ORDERS.

The calculation of correlations between orders or marks is frequently of great use in psychology and education. The student will meet such statements as that a test, given to a class of boys, correlates with the teacher's estimate of their intelligence to the extent of 0·6; or that the order in an examination in Arithmetic, correlates with the order in another examination given a week later, only to an extent of 0·4 or 0 5.

It is desirable for the student to get a general idea as to what is a large, and what is a small coefficient of correlation.

He will learn that good intelligence tests correlate with one another often to the extent of 0·7 or 0·8. The correlations of examination orders afford many examples. Thus, the correlation between the orders in the School Certificate Examination in Mathematics and the order of merit given by the teacher of the same class, is on the average about 0·75. In History and English it is about 0·65.[1] In an enquiry among about a dozen different towns I found that the orders in the Entrance Examination to Secondary Schools, correlated with the orders of merit of the same pupils in the Secondary Schools, four or five years

[1] See *Secondary Schools Examination Statistics*, by J. M. Crofts and D. C. Jones (London, 1928).

later, as little as 0·3 or 0·4, and sometimes considerably less—no more than 0·1 or 0·2.[1] That means that there was little more resemblance between them than might happen by pure chance

We shall see in the chapter on Intelligence Tests how valuable a tool the coefficient of correlation has been in selecting the best tests. In the following paragraphs we may mention briefly one or two more general uses of the method.

To Find the Reliability of a Test.—Suppose I have put my class through a series of tests in visual rote memory, being anxious to know the order of merit of the children in this respect. How am I to know whether the test is a reliable one or not? Does it really indicate the true order of merit of the children in respect to the mental work involved in this test or have accidental variations been at work, *e.g.* was one child unusually careless, another very fatigued, or did the material used favour one child more than another? Now I can get a figure which will indicate to me, and to any others to whom I quote my results, the degree to which this test can be relied upon. The method is as follows.

Having already given one test in visual rote memory and so obtained one order of merit for the class, I proceed to give a similar rote memory test on another day and with new material This will give me a second order of merit for visual rote memory. Obviously the more alike my two orders are, the more reliable my two tests are

[1] See *The Reliability of Examinations*, by C. W. Valentine, with the collaboration of W. G. Emmett (Lond Univ. Press, 1932) or *Examinations and the Examinee*, by C. W. Valentine (The Birmingham Printers, 1938). The former book gives some diagrammatic representations of correlations.

proved to be.[1] The extent to which the two orders are alike can be shown by finding the coefficient of correlation between them in the way described above. The number obtained is called the "reliability coefficient," and should ideally be a fraction approximating to one. The experimenter should not be *satisfied* with a reliability coefficient much below 0·8 or 0·7, though experts frequently get lower figures. Most of course depends upon the nature of the test itself and upon the number of subjects tested.[2]

It will be seen that such a method of checking the reliability of mental tests or examinations may be applied in various ways. Thus we may find the correlation between (i) the rote memory tests done on a certain school class by one experimenter and (ii) the results of similar tests done on the same children by a different experimenter. This may betray variations of results due to variation of method or to some personal influence. Such a "personal factor" enters not only into psychology tests but into ordinary school examinations. If two teachers were asked to examine the same class in the same subject on two successive days and to compare their orders, there would probably be considerable surprise at the great difference of order due to the personal element of the teacher. Indeed

[1] Of course within the limits set by the nature of the test itself and by the number of pupils. Obviously the smaller the number of pupils, the smaller the likelihood of great variations between the two orders.

It is better to get another experimenter to perform the second test, if an equally reliable one can be secured. The correlation of the two orders is then also a check upon any individual peculiarities in the way of presenting the material which may possibly affect the results.

[2] See note on the "Probable Error" at the end of this chapter for a further means of estimating the extent to which one can rely upon one's results.

it has been found that two examiners, marking even the same set of examination papers, may give independently orders which do not correlate more than to the extent of about 0·6.

The Use of Correlation in Schools.—The teacher may make use of the method of correlation described to find the reliability coefficient for any psychological tests (*e.g.* visual or auditory rote memory) to which he has submitted his pupils.

The various uses of correlation already mentioned in connection with school subjects may also prove of interest to the teacher. Thus he may test the stability of his own examining of his pupils and of their work by finding the correlation between the orders of two similar examinations given at about the same time.

A further question of great interest is the following. What subject gives an order of merit which comes nearest (of all subjects) to the order of the class in "general intelligence"? The teacher may first draw up an order of general intelligence for his class. He must be extremely careful to avoid being influenced by personal likes and dislikes. He knows quite well that the passive obedient boy who gives so little trouble and who agrees so willingly with his teacher is not by any means necessarily more intelligent than the independent rebel, nor has the diligent boy always more of what we ordinarily understand by general intelligence than is possessed by the comparative idler, though no doubt in the long run good general capacity makes a boy take more readily to school work. In particular the teacher must try not to be influenced too much by the performances of the boys in work in which proficiency is largely a question of rote memory.

It would be well, if the class is taken by several masters

in different subjects, for each to draw up independently an order in general intelligence, after which the lists can be considered and discussed in council and a final average list agreed upon. Naturally in this the word of a teacher who takes the class in several subjects, or knows the boys in some out of school activities, should have more weight than that of the teacher with only takes one subject

This final order can then be compared with the order of merit in the various school subjects. By finding the various correlations the teacher will know then to what extent each of the school subjects (as taught in that particular school), Latin, Mathematics, Science, Woodwork, etc, correlates with estimated general intelligence. Similarly he may find to what extent any of these subjects correlates with the more dependable order of general intelligence given by a good set of intelligence tests.

We shall find further uses for this method of calculating correlation when we come to discuss tests of general intelligence in Chapter XXI.

The Calculation of the Probable Error.—The larger the number of subjects taking part in the tests and the higher the coefficient of correlation, the less is the correlation discovered likely to be due to mere chance.

The figure known as the "probable error" gives us an estimate of the extent to which mere chance is likely to cause a correlation. If Spearman's "Foot-rule" is used, the probable error is equivalent to $\frac{0.43}{\sqrt{n}}$, where n = the number of persons on whom the tests are performed.[1] The formula which should be used for the more exact

[1] See Spearman's article in *The Brit. Journ. of Psychology*, Vol. III., p. 96.

method of calculating correlations (given on p. 59) is as follows :—

$$\text{P.E.} = 0{\cdot}7063 \times \frac{1 - r^2}{\sqrt{n}}.$$

Any coefficient less than three or four times the P.E is not worth considering.[1] If the number of persons is much below thirty the coefficient of correlation should be about five times the probable error if it is to be regarded as a proof of a real correlation between the two orders.

[1] See W. Brown and G. H. Thomson, *The Essentials of Mental Measurement*, p. 103. For a more elaborate method of calculating the correlation of scores or marks and the probable error, see C. S. Myers and F. C. Bartlett, *Text-book of Experimental Psychology*, p. 123, or W. Brown and G H. Thomson, *Essentials of Mental Measurement*, Chap. V

CHAPTER X.

THE SUPPOSED "IMPROVEMENT OF THE MEMORY" AND THE TRANSFER OF IMPROVEMENT.

Experiment XXII.

Interpretation of Results.—When all the results of Experiment XXII. are before him the student should carefully compare the score for Test A, taken before the practice period, with the score for Test B, taken after the practice period. Suppose that poetry has been learned during the practice period, has this resulted in an improvement in the capacity for learning poetry as shown by Test B compared with Test A? If so, does the control group show any improvement on the poetry test of Test B?

Further, has the exercise in the learning of poetry resulted in any improvement in the other memory tests, with letters and nonsense syllables, *i.e.* is there a *general* improvement of the memory?

In the chapter upon rote memory we saw that it was undesirable to speak of memory in general, and that we ought rather to regard memory as an inclusive term covering various functions, such as visual memory, auditory memory, etc.

Recent researches also suggest that a general memory improvement is not necessarily brought about by practising the learning and recall of one kind of material

If the results of a large class in Experiment XXII. are considered, one fact at least is likely to appear, namely, that there is little or no general improvement in all the kinds of memory tests as the result of practice in poetry or vocabularies,—at least no greater improvement than the results given by the control group may show to be attributable to the practice gained in Test A itself, or to the lesser difficulty of Test B.

It used to be thought that the study of, say, Latin "strengthened the memory," so that a boy could remember history or poetry better for having ground away at Latin verbs. We have now good reason to believe that practice in memorising any given material will effect relatively little improvement in the learning of a second kind of material, except in so far as the two materials resemble one another. This statement, however, only seems to be partially true and we must modify it somewhat.

Mode of Transference of Improvement in Remembering.—Let the student examine his own or the class results in Experiment XXII. He may very likely find that practice with poetry appears to have resulted in an improvement in the power of memorising poetry. One group of a class of my own improved in this respect 15 per cent., though the control group showed no such improvement. But is this necessarily due merely to the fact that we are dealing with poetical ideas? Probably not, for it has been found that practice with poetry may be followed by increased scores in the memorising of nonsense syllables, if these are rhythmically arranged.[1] Here the only resemblance (let us hope) is the common element of rhythm.

[1] See W. G. Sleight, "Memory and Formal Training," *Brit. Journ. of Psychology*, Vol. IV.

Possibly the sensibility to the influence of rhythm, or the tendency to make use of it in learning work, is increased by such practice with poetry, more especially in the young, where there is capacity for such development.[1]

This greater sensibility, or facility, appears to aid the assimilation or the retention of the rhythmic material. If the student examines his answers to the rhythmic nonsense syllables test, he may notice that sometimes he has paired a nonsense syllable with its wrong partner, but that he has at least given it its correct position as regards the beat and rhythm. This often happens, and it shows how strong may be the association between a syllable and its appropriate stress or beat. In a class of my own, the group which had practised with vocabularies showed an improvement of 20 per cent. in the learning of pairs of nonsense syllables, though the control group scarcely showed any improvement in the same tests. Possibly here, too, the facility which had been gained in using rhythm in the learning of vocabularies proved useful in the subsequent learning of nonsense syllables; but a few of such experiments are not enough for proof.

In a somewhat similar way it seems possible for the capacity for visualisation (or rather for the habit of using it in learning) to be increased through practice in learning, say, nonsense syllables or vocabularies. This increased use of visualisation may then reveal itself in an improvement in learning material of quite a different nature, providing that visualising can be made use of here also. Thus if the student has learned to make more use of his visual imagery in the course of learning vocabularies, he may find that he improves in the visual letter test in Test B without

[1] Many adults have no doubt reached a stage at which no better use of rhythm can be made.

doing so in the auditory letter and figure test. He should, as always, carefully compare his results with the introspective remarks made at all stages of the experiment. Such remarks may be able to explain apparent anomalies. Thus those members of the class who visualised in the auditory test may find that they improve even in this test as the result of practice in visualisation.

We see then that there may be a kind of transfer of memory improvement through practice in one kind of material to the capacity for learning another kind, through such common functions as visualisation or rhythmisation. But it is found that slight changes in method may easily disturb this transfer through a common function. And there is evidence that, in any case, any apparent transferred improvement is not of a permanent nature.

Great improvement may, of course, take place where the material I learn now is itself a help in learning and remembering other material. For example, if my mind has been well stored with historical facts I shall learn and remember new historical facts more easily if these new facts are connected with and can be linked on to the old ones.

The student should consider the results of Experiment XX., and all introspective observations, with these further questions in mind: (1) If a transference of improvement is obtained through some common function (*e.g.* visualising or rhythymising) is it necessary or helpful for him to be aware of and to use deliberately that common element? (2) What changes, if any, occurred in the general attitude to the practice work or the tests? (3) Did interest increase or decrease, and with what probable consequences?

The whole question of the transference of memory improvement is a very complex and difficult one, and in this brief account we have had to pass over many problems.

Among other things we have not discussed the distinction between (1) improvement of the power of learning and (2) improvement in the power of retaining, *i.e.* in memory proper. The distinction is interesting theoretically, but from the educational point of view it is not so important as it may appear. For even if all improvement is really improvement in the power to learn, this means that a given amount of material is really learned in a shorter time, and so some time can be spared subsequently for revision; consequently, with a double learning the work will finally be remembered better.

Finally, it must be remembered that experiments on the transference of memory improvement have only extended over a relatively short period. It is possible that there would be more "transference" as the result of the prolonged memory work of ordinary school work. The main point of interest, however, is that direct specific improvement in a given period, seems to be much greater than transferred improvement, if indeed the latter occurs at all.[1]

[1] For fuller evidence and discussion of this question see *Educational Values and Methods*, by W. G. Sleight, on whose research Experiment XXII. is based.

CHAPTER X.

THE ACQUISITION OF SKILL. THE METHOD OF TRIAL AND ERROR.[1]

Experiments XXIII., XXIV. and XXV.

The Method of Trial and Error.—The experiment in mirror drawing illustrates what is perhaps the most fundamental and elementary method of learning, viz. learning by trial and error, or, as it might better be called, by trial and elimination of error.

Suppose I have a safe, with a combination lock of which I know the key to be CXB. Knowing this I can at once set the letters in their right position and open the safe. Here I am applying knowledge of a fact in order to do something.

My procedure is fundamentally different if I try to learn such a game as golf. No doubt to some extent I can make use of knowledge, *e.g.* advice and information from an instructor. But to a large extent any progress I make in the game is due to a much less deliberate and less conscious process. I hit at a ball and miss it. I take another aim, and this time my procedure is modified. Certain muscular contractions which led to my previous error tend to be avoided, and this time I succeed in making a hit, though a bad one. Yet I may be quite

[1] In connection with this chapter the student may read Stout, *Manual of Psychology*, pp. 375-384

unable to say exactly what modifications took place in the second stroke, and at the third stroke I may miss as badly again as I did at the first stroke. Only very gradually are the wrong movements eliminated and the right ones stamped in. Probably the thrill of pleasure experienced when we feel that we have done the right thing helps to stamp in the tendency towards the performance of that right action, so that on another occasion it is more likely to recur than it was previously.

In learning golf thus, I am using the method of trial and error, and this method is constantly used by children in developing motor habits, not only in the very early stages, *e.g.* in such actions as grasping, walking, throwing a ball, etc., but also in learning to draw and write, or to play a musical instrument.

Value of the Mirror-drawing Test.—It is chiefly in order to bring home to the student the nature and the extreme difficulty of this method of trial and error that the mirror experiment is given. The child in learning to write has to coordinate certain definite hand movements with sight. Similarly in the mirror experiment the student has to establish new coordinations between hand movement and the visual impressions reversed by the mirror. The gradual and irregular way in which such coordinations are established will be readily seen from the curves of times and of errors, especially the latter. As we have already indicated, the method of trial and error is especially characterised by this variability. Thus to-morrow I may be worse at golf than I am to-day, and similarly the child may be worse at writing, but he does not therefore deserve a scolding for carelessness. Only very gradually can the wrong movements be eliminated and the right coordinations set up.

Below are given the actual curves of one subject for time and errors in Experiment XXI. Note especially the great irregularity of the error curve. Sometimes subjects improve more rapidly as regards errors, but do not reduce

MIRROR-DRAWING CURVE.

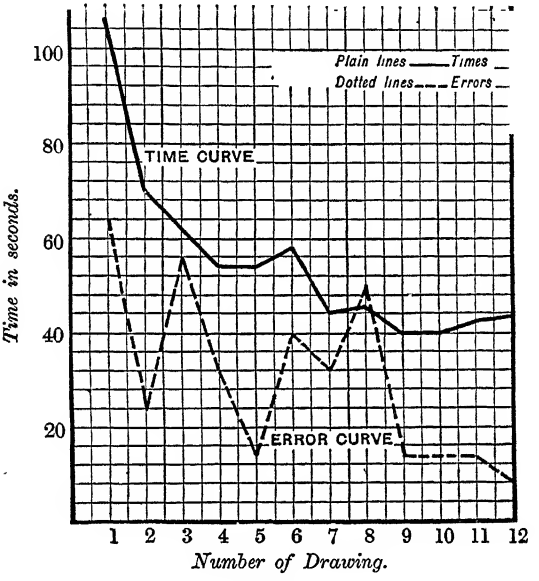


Fig. 10.

their time so much. Others reduce their time more rapidly, but make very little reduction in the matter of errors.

It has been found that, in the course of learning motor habits, *e.g.* in learning typewriting, the curve of progress here and there shows a plateau, where for the time it

appears that no progress is being made. Possibly it indicates the occurrence of a rest period, which, as it were, the mind unconsciously takes when it has been hard-pressed.

The experiment will provide for the teacher a concrete example of the difficulties that children have to face in developing the proper coordination of muscles for whatever purpose this may be necessary, and of the gradual and irregular progress which is essentially characteristic of this method of learning. The work of the child in learning to write or draw will at least be no less difficult than the mirror drawing is to the student, for the latter simply has to learn to reverse the directions of all his usual movements. The continuation of a movement in a straight line, once the student has started in the right direction, is already partly provided for by previously acquired motor habits. Furthermore, the adult sometimes quickly works out the principle that he must move his hand away from the mirror when he wants his pencil to move towards him. Of course in so far as such a principle is applied the method is no longer purely a method of trial and errors

The interesting experiments made by Köhler on apes, seem to prove that they may at times learn by methods superior to that of "trial and error"; but that does not prove (as some psychologists of the *Gestalt* school seem to imply) that the method is never followed, in part at least, in some of the learning processes of animals and men.

Mirror-drawing as a Test of Motor-habit Formation.—According to Professor Burt, mirror-drawing makes the most successful test of habit-formation in children, though habits of skill are much too specific to be completely measured by any one test.[1]

[1] See C. Burt, *The Backward Child*, p. 503.

Burt not only found a good correlation between this test and estimated intelligence, but he found that skill acquired with the right hand, was transferred to a considerable extent to the left hand among normal children but not among the dull.

This transference (which Starch and others found in their early experiments) is itself a point of interest, and suggests that more is implied than mere bodily skill involving only one hemisphere of the brain, and that there is some general principle of procedure which is grasped more or less explicitly.[1]

[1] On the various 'levels' or elements of mental processes involved in mirror-drawing, advanced students will find interesting material in the article by M. Gopalaswami, "Intelligence in Motor Learning," *Brit. Journ. of Psych.*, 1924, Vol. XIV.; also in the article by Professor Burt on "Experimental Tests of General Intelligence," *Brit. Journ. of Psych.*, 1909, Vol. III. Another article by Gopalaswami shows that the best results are gained in such motor learning by learning one part of a pattern first, then a second part, and then the two together, then a third, and so on. (See "Economy in Motor Learning," *Brit. Journ. of Psych.*, Vol. XV)

CHAPTER XII.

MENTAL WORK AND FATIGUE.

Experiments XXVI. and XXVII.

Discussion of Results of Experiment XXVI.—The subject of fatigue is a highly complex one and has received an amount of attention from experimental psychologists proportionate to its importance. We must here confine ourselves to a brief and simple discussion bearing directly upon the experiments given.

The student should first study the nature of the curve of work in Experiment XXVI. in connection with his own introspective remarks. It is frequently found that the curve is affected by the following factors.

Factors Affecting the Work Curve.—In the first period of work there is often a good performance due to the *novelty* of the experiment. This may be followed by a drop, but the curve soon rises owing partly to *practice*, and partly to the fact that the subject "warms" to his work. This is called *incitement*. If the work is sufficiently prolonged, boredom or *fatigue* eventually sets in, showing itself as a rule chiefly in a larger number of errors rather than in a decreased amount of work. The amount of work may keep fairly steady for a time, any fatigue being balanced by improvement due to practice. For this reason (among others) the graphs often show *plateaux*. There are also frequently, of course, fluctuations at this period. Some psychologists believe that the feeling of fatigue causes the subject to rest somewhat for a time, so that he recuperates; and thus shortly after a drop owing

to fatigue the curve may suddenly rise again as a result of such recuperation,

Finally, if the work is sufficiently prolonged, there is a marked deterioration, the quantity of work done dropping, as well as the number of errors increasing. If at the beginning of the last period a warning is given to the subject that he has now reached the last section of his work a final spurt at the end may be observed, though an increase in the amount of work done in this last period may be more than counterbalanced by increased inaccuracy.

We have here described what may be called an ideal curve, but some of these variations may not appear in any given curve. Throughout the book we have emphasised the enormous importance for the experimental psychologist of the fact of individual variations, and this fact is very evident in the case of fatigue.

Analysis of a Fatigue Curve.—In Fig. 11 is given an actual curve of a subject who worked at the crossing out of four letters in continuous prose for twenty-two minutes. Let us study the given curve in detail. In the first place there is in this case no specially good performance in the first period of two minutes. Practice effects, however, are very quickly shown, culminating in the maximum score of 143 at eight minutes, though this improvement is somewhat discounted by the considerable increase of errors during the same period. There follows then a marked drop in the amount of work (see below), though the errors slightly increase. Then there is a suggestion of the rhythmic return of more efficient work as the work curve rises slightly and the errors decrease. Then comes a second drop in the work done, and the signal given at the twentieth minute that the last period had arrived only

succeeded in arresting this drop in the amount of work done at the expense of an enormous increase in the number of errors.

FATIGUE CURVE.

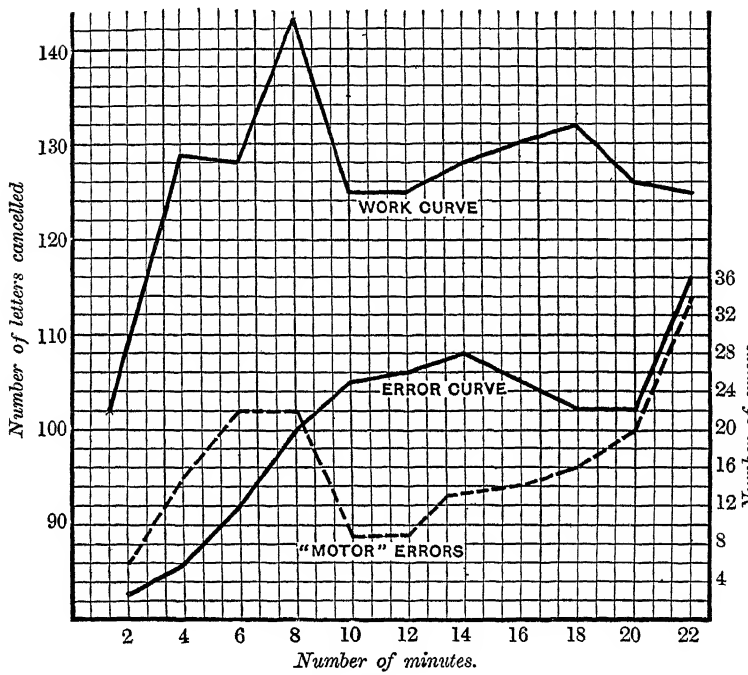


Fig. 11.

We still have to consider the *motor errors*, i.e. the cases in which the subject failed in her attempt to cross out the letter properly, putting the mark beside the letter instead of through it. These errors are indicated by the motor

curve above. From a consideration of this motor error curve we may conclude that the great drop in the work curve after the maximum of 143 is reached is partly due to the student adopting an attitude of greater carefulness in manipulating her pencil, for here the motor errors decrease.

The fact that fatigue was present at the end of the test is emphasised by the great rise in the motor error curve co-incident with the rise in the error curve proper. With the warning that the last period was reached the subject attempted more rapid work, but succeeded only in increasing her number of errors of both kinds, while the amount of work showed no increase. As stated before, neither kind of error (motor error or omission) is subtracted from the total number of letters crossed out as shown in the work curve.

The subject whose curve is shown above was unusually quick in showing the effects of fatigue. There seem, however, to be some subjects who do not show fatigue either by a lessening amount of work done or by an increasing number of errors, even in as long a period as two hours spent in arithmetical calculations. There are doubtless marked individual variations in the extent to which a subject "works himself out." Some work steadily at a pace which is not really their highest possible, though they may not be conscious of this. This fact is shown sometimes by the sudden increase of which they are capable when they hear that the last period is reached. Others, on the other hand, work up to their full capacity all the time, and an effort to spurt only shows itself, as we have seen above, in a greater number of errors.[1]

[1] As far as my own observations go an increase in the amount of work due to a spurt at the end is found more frequently among

Fatigue and Boredom.—Those who find that they can do much better with a spurt may have imagined that they were really fatigued: indeed they may have felt very tired. Probably they were suffering from boredom more than from anything else. Indeed it is often difficult to distinguish between fatigue and boredom. All students know how, when they are feeling tired with their work, if a point of special interest arises, all thoughts of fatigue may be forgotten and work may go on quite vigorously again. In such cases we are probably only bored, rather than fatigued in the special sense in which experimental psychologists are now using the word, namely as indicating *a reduced capacity for work.*

In this sense fatigue must be distinguished not only from boredom but from *the feeling of tiredness.* Normally the feeling of tiredness acts as a safeguard against excessive work, but it seems possible for some subjects to feel "tired" when there is no real fatigue in the special sense used above. On the other hand, in some cases a state of serious fatigue seems to be reached before adequate warnings are given by the feeling of tiredness.

The testimony of a person as to his own state of fatigue is thus seen to be not always reliable. The student should carefully compare his own introspective remarks as to his feelings of fatigue with the objective record of the work done. It will be found also that one's impressions as to the amount of work done are often untrustworthy. Thus one subject wrote that he seemed to be going much more slowly than in a previous test, whereas he was really going faster.

men than among women. Whether this is due to the slower onset of fatigue with men, or to the fact that they do not "work themselves out" as conscientiously as the women do, I leave the reader to judge.

Mechanisation.—One further point the student should observe, namely the tendency towards "mechanisation." As we have already seen in Experiment VII., the simpler the work, the more readily does it tend to become mechanical. This is in itself a means of relieving higher mental processes from some of their work, and so of lessening their fatigue.[1] The writer finds that in the case of many subjects, himself included, the onset of fatigue seems to show itself partly in the occasional failure of such mechanisation of mental work and in the recurring necessity for very deliberate attention to the method of working.

The Effect of a Pause.—As an interesting variation of the method of Experiment XXVI. the introduction of a short pause in the middle of the work period was suggested. This naturally delays the onset of fatigue. But if the pause is very short, more is lost through the loss of incitement and the necessity of "warming up" to the work again than is gained in any other way. On the other hand, if the interval is indefinitely prolonged, something is lost through the partial disappearance of the improvement due to practice. The ideal pause, which gives the maximum amount of work, naturally varies with the individual and according to the nature of the work and the length of the total work period.

The following is an interesting curve showing the work done by a student with the multiplication test given in Test B, Experiment XXVI. Half-an-hour's work at the test was followed by the usual college interval of ten minutes, after which a further period of sixteen minutes was spent at the test.

[1] In some mental tests it would seem that the rapidity with which work can be mechanised is some indication of the intelligence of the worker

From the curve it will be seen that practice effects are very obvious in the first quarter-hour's work, but little

FATIGUE CURVE SHOWING EFFECT OF INTERVAL.

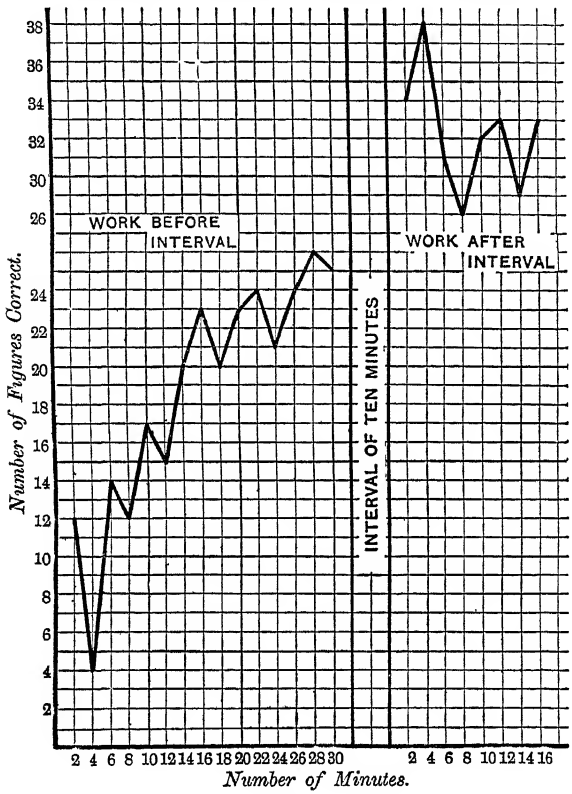


Fig. 12.

further advance is made in the second quarter-hour. Yet much better work is done after the interval, though there

has been no further practice. The explanation must be that fatigue was overcoming any further tendency for the curve to rise through practice effects in the second quarter-hour. The interval proved to be of serviceable length, largely removing the effects of fatigue and allowing the effects of practice to show themselves more completely. (The number of errors made by the subject was inappreciable.) In some industrial processes astonishing increases in the total output of work have been obtained by discovering a suitable rest pause and enforcing it.

Discussion of the Results of Experiment XXVII.— We turn now to Experiment XXVII., in which the fatigue tests are applied at different times of the day or after varying kinds of work. Here we have a different principle of experiment involved. Previously, in Experiment XXIV., we were estimating fatigue due to arithmetical work by changes in the amount and accuracy of the work itself. Now we are concerned with the fatigue due, say, to an hour's physical exercise, and we are seeking to detect its presence by introducing a test which involves a different kind of work. Such are called *interpolation tests.*

This method calls for comment. Interpolation tests involve the assumption that the fatigue produced, say, by Latin or gymnastics will result in a lessened capacity for doing the arithmetic of the fatigue test. Now it is well known that after a change of work we often feel a renewal of vigour, and some writers question whether there is any "transfer" of fatigue. In some cases indeed a period of mental work actually seems to increase the amount of physical work done in the succeeding work test. On the other hand it is evident that we cannot continue indefinitely the renewal of mental vigour by the mere changing of our work, for a kind of "general" fatigue sets in. A

discussion of the solution to the apparent contradiction here would carry us too far into the physiology of fatigue. For practical purposes we may regard it as a question of degree. Each special kind of work causes fatigue particularly for that special work, and if sufficiently prolonged it also contributes to general fatigue.

The student will thus be prepared for very varying results from his interpolation tests according to the nature of the work which has preceded them. Normally one might expect that the greater the change of work, the less will the fatigue due to the previous work be shown in the fatigue test. But this rule is liable to at least one marked exception. One of the most valuable results of fatigue tests has been to show that vigorous physical work is not always a good preparation for immediately subsequent mental work, although the change is so great. Some writers indeed go so far as to regard drill and gymnastics as the most fatiguing of all school work.[1]

The Use of Fatigue Tests in Schools.—It should not be difficult for the teacher to apply the methods of experiment illustrated in the tests on fatigue, in the course

[1] The writer is very conscious that this chapter is far from being a complete discussion of the problem of mental fatigue, which is of course complicated by the interference of bodily fatigue, the necessity for recurring intervals for the nourishment of the bodily organism, etc. For a further discussion the student is referred to E. L. Thorndike, *Educational Psychology*, Vol. III., Myers and Bartlett, *Text-book of Experimental Psychology*, Chapter XIV.; Spearman, *Abilities of Man*, Chapter XVIII.; C. S. Myers, *Mind and Work*, Chapter II.; Rusk, *Experimental Education*, Chapter XIII.; Offner, *Mental Fatigue*, translated by Whipple; and to the articles mentioned in the Bibliography.

of ordinary school work, should he so desire. He may quite well use a series of very simple arithmetical calculations, well within the capacity of the children of the class to be tested. As such are frequently used in school for practice in accuracy, he need not feel that he is wasting time from the point of view of the ordinary school work.

If the amount and accuracy of work done is to be the criterion of fatigue the work selected should conform to two conditions. In the first place, as already stated, it must be well within the power of the children to perform fairly accurately when at their best. Secondly, the work must be throughout of equal difficulty, as far as this is possible.

The teacher should be able to provide long lists of short sums that will conform sufficiently to this condition. He may speak of the test as a kind of competition to see which pupils can work most quickly. Such tests might be applied for any of the purposes already referred to in the experiments for adults.

The Method of Equal Groups.—In order to allow for the effect of practice the following plan may be used. After three or four preliminary tests with the given material, the class may be divided into two equally efficient groups, A and B, upon the basis of their performances in these preliminary tests.[1] Group A may now take a second series of three or four tests at, say, some time in the morning session for several days Meanwhile group B may do the same test at the end of the afternoon session of the same days. Or group A may do the second series of tests after, say, physical exercises, and group B after sedentary work. As groups A and B did equally well in the first series of tests, any marked differences of results between the results of group A's second series of tests and group B's second series

[1] See p. 61 for a method of division into groups of equal efficiency.

of tests may probably be ascribed to the fact that they were either done at different times of the day or after subjects producing different degrees of fatigue, or at least of what we may call "fatigue for arithmetic."

In a similar way a teacher may make use of several of the tests already given in this book, more especially rote memory tests, or Experiment VII. on the division of attention.

Fatigue and the School Time-table.—The teacher may also perform experiments to find the degree to which different kinds of work suffer through being done at the slacker periods of the day. This is obviously an important question with a view to the best placing of subjects in the time-table.[1] Much research remains to be done in reference to this problem, though some important results have already been obtained. There is, for example, some evidence that the fatigue experienced by many elementary school children towards the close of an afternoon's session unfits them for arithmetical problem work to a greater extent than it does for rote memory work. To deal with such a problem we do not of course need to interpolate special fatigue tests, but to compare the work done in arithmetic by a group of pupils during morning hours with the work done by the same group, or, better, with a group of equal capacity, working in the afternoon, and then to compare similarly the work done in the learning of poetry or of tables by two equal groups, one working in the morning and the other in the afternoon.

[1] Where different subjects are taught by different teachers the possible influence of the teachers upon the development of fatigue must be kept in mind. Thus a class may be more fatigued after a lesson in arithmetic with teacher A than after a lesson on exactly the same topic with teacher B. This question of the influence of the teacher upon fatigue may itself be made a subject of experiment.

This division into groups may prove an interference with the school routine, but as the test work is to be done in silence, the second group of the class can also be doing some silent work, such as the learning of poetry, while the first group are doing the arithmetic test, the first group learning the poetry when the second group are doing the arithmetic test. Thus the whole class will be occupied with some useful work.

Dictation as a Fatigue Test.—The difficulties due to the complicating effects of practice can be largely avoided if such a subject as Dictation is chosen as a fatigue test, only those errors being reckoned which cannot be attributed to real ignorance, but rather to what the teacher would call usually "carelessness." The dictation must be given slowly, so that there is no need for any child to hurry. Under these conditions the dictation test has yielded striking results. Thus three classes tested before school and after school in the afternoon gave the following number of such "slips" (per 100 letters and per 100 pupils).

Slips in Dictation.

	1st class	2nd class	3rd class
Before school	123	121	72
After school	156	145	102

The table shows an average increase in the number of errors of about 30 per cent. due to afternoon's work.

Fatigue and the Length of a School Day.—The conditions under which school work is done (ventilation, adequate food and sleep, etc.) vary so much that it is impossible to make wide generalisations on this topic. The general trend of thought is towards the view that most apparent cases of overwork in school are due to the

lack of adequate exercise or food, or to worry or fear about progress, rather than to actual overwork. One careful investigator, for example, found that the mental efficiency of children over nine years of age remained constant from 9.30 a.m. to about 2 30, as tested by simple arithmetical work; and there was only evidence of fatigue in children under nine after about a five-hour day.[1]

In another school, although special attention was paid to adequate periods of recreation, it was found that work deteriorated in most classes in a long afternoon; but there was no evidence that it was worse in the thirteenth week of the term than earlier on.[2]

A short experimental enquiry on evening school pupils suggested that work might be spoilt if put only one hour later than usual in the evening.[3]

In another school an experiment was made to try the effect of having preparation at the end of afternoon school instead of giving homework at night,—the pupils being between the ages of eleven and fourteen. It was concluded that one hour's preparation, from 4 p.m. to 5 p.m, immediately following the end of school, produced noticeable fatigue in most pupils, but not when the ordinary school work was concluded at 3.20 and the preparation taken from 3.20 to 4.20.[4]

[1] See Shepherd Dawson, "Variations in the Mental Efficiency of Children during School Hours," *Brit. Journ. of Psych.*, XIV., 1924.

[2] See W. J. Stainer, "Rate of Work in Schools," *Brit. Journ. of Psych*, XIV., 1924

[3] See W. H. Winch, "Mental Fatigue in Adolescent Pupils in Evening Schools," *American Journ. of Educ. Psych.*, Vol. I.

[4] See A. Sutcliffe and J. W. Canham, "Mental Fatigue and a Longer School Day," *Brit. Journ. of Educ Psych.*, VI., 1936.

Incentives and Fluctuations.—Obviously, the steadiness of a work curve will be affected by the incentive to keep up one's record. By the ingenious device of rewarding children with pennies, when they beat their previous day's records, Professor J. C Flugel found that there was little drop in the twenty-minute work curves in arithmetical calculations among elementary school children.[1]

He found, also, great individual differences in the extent to which the pupil's work fluctuated. Another investigator has given evidence that oscillations of work-output tend to change their frequency according to a regular pattern [2]

[1] See his "Practice, Fatigue, and Oscillation," *Brit. Journ. of Psych., Monograph Supplement,* XIII.

[2] See S. J. F. Philpott, "Fluctuations in Human Output," *Brit. Journ. of Psych., Mon. Sup.,* XVII.

CHAPTER XIII.

THE TRANSFERENCE OF EFFECTS OF TRAINING.

Experiments XXVIII., XXIX. and XXX.

Experiments XXVIII. and XXIX. are based on those by Thorndike and Woodworth[1] and others. They have a distinct bearing on the question of Faculty Psychology and Formal Training, and show the danger of talking of Perception, Observation, Judgment, etc., as simple "faculties," any form of practice of which will give *equally* a general training for all forms of work done by that "faculty." The transference to somewhat different kinds of work, even if it occurs at all, almost always involves a certain decrease in the amount of improvement; and sometimes practice of one mental function may actually interfere with another called by the same name in popular psychology. Thus, training in the rapid "perception" and selection of one part of speech may in some cases spoil the selection of other parts of speech, largely by fixing the specific habit of still looking for that part of speech with which practice was done The explanation of individual differences should be sought through introspective observations.

[1] See E. L. Thorndike, *Educational Psychology*, Vol. II., pp 397 ff.

In these experiments the students should note:—

(i.) Whether he can trace definite factors learned in the practice process which can be used in the different work of the final test; either (*a*) mechanism or associations, or (*b*) ideas of method, *e.g.* looking out specially for the least common letter or part of speech; checking undue haste or a general tendency to over-estimate sizes; using $\frac{1}{2}$ in. or $\frac{1}{4}$ in. as a unit and trying to see how many units are in a given line.

(ii.) Whether there is any "transferred" improvement even when no common factor is consciously used.

(iii.) How far a change in "general attitude" to the work, *e.g.* growing keenness, may explain a transferred improvement.

(iv.) Whether there are any signs of habits acquired in the practice hindering the work of the final tests.

(v.) Cases where a definite improvement in some particular mental process is not transferred to work of another kind (though the process is certainly involved) owing to disturbance due to the new factors involved.

If tests can be done on groups of children the student should note the relation between general intelligence and the tendency to show transference of the kind mentioned

Note. In this chapter and in that on the training of memory the term "transference" is used as it is commonly used in such discussions. It should be noted that the word must not be interpreted too literally.

On the general question of "transference" see A. G Bills, *General Experimental Psychology*, Chapter XIII.; W. C. Bagley, *The Educative Process*, Chapter XIII., and D. Starch, *Educational Psychology*, Chapter XIII. The problem of a general training in thought, precision, etc., through language study is discussed in three chapters of my book on *Latin; its Place and Value in Education.*

CHAPTER XIV.

THE SPEED OF READING AND ITS IMPROVEMENTS.

Experiments XXXI. and XXXII.

Individual variations in the rate of silent reading are very great. In a class of about fifty graduates, for example, one usually finds that, tested by the reading of quite simple material, the fastest reader will read three times as much as the slowest. Now it is sometimes said that slow reading is no disadvantage as it means greater reflection and better absorbtion. Unfortunately, however, one has to read a good deal of material which neither needs much reflection nor deserves absorption. There is a good deal of evidence also that the fast reader is not inferior to the slow, even as regards the relative amount of material retained; and that absolutely he retains a good deal more. It is, however, wrong to assume as some writers do that capacity for reproduction is the sole test of the value of the reading done. Criticism and the linking up of the ideas with previous knowledge may be of even greater value, and these would of course slacken the speed of reading.

It is hardly possible to find whether the slow reader gains more than the fast by way of reflection. There is evidence, however, that the slow reader in his reproduction

introduces more ideas not in the given material read than does the fast reader, and this point should be noted in studying the results of Experiment 31, II This in itself, I think, suggests that the slow reader is "filling in" with his own thoughts the ideas expressed in the words read. This may mean less accurate reproduction but better assimilation.

Nevertheless the reasons given above appear to justify the view that it is very useful to be able to read very fast when one wishes to, and that the slowing of speed through mere mechanism and not through reflection is undesirable.

Imagery and the Speed of Reading.—Students should enquire into the connection between speed of reading and imagery. It is not possible to draw up an order based on intensity of imagery, as we cannot be sure that what one man calls vivid imagery is more intense than what another calls moderate. We can only consider extremes. In one class of fifty students the ten fastest and the ten slowest readers gave very similar reports, as a group, on auditory imagery. But there was a great difference in reference to motor imagery, the ten fastest having practically no motor imagery, though all the ten slowest reported motor imagery. Some readers cannot get rid of this motor imagery which seems to slow down their reading. Others by practice seem to be able to repress it, and improve their speed. It is possible that this accompanying motor imagery is partly due to innate characteristics and partly due to long continued reading aloud and an inadequate amount of silent reading at early stages.

There are of course other factors affecting the speed of reading; the number of eye pauses in the line, the length of those pauses, span of visual apprehension, and the

rapidity of eye movements. These are probably more important than imagery in determining speed, but they need special apparatus for their proper study.[1]

Improvement with Practice.—With much less practice than that suggested for Experiment 32 I have found that a practised group will gain twice as much on their earlier record as the unpractised. Note whether the slower readers necessarily gain most. Observe also, if possible, any variation of improvability with age. (This should be especially noted in testing children for speed. In this case a test of comprehension should be given to ensure genuine reading.)

Note also whether any difficulty of apprehension of the material leads to motor or auditory imagery, or even to reading aloud.

Some students find that imagery decreases and speed increases as interest increases.

[1] For a description of these factors the reader should refer to E. B. Huey: *The Psychology and Pedagogy of Reading*, and W. H. Smith, *The Reading Process*. A fuller treatment of points dealt with in the experiments will be found in an article by the present writer on "Some Experiments on the Speed of Reading and its Improvement." *Forum of Education*, Vol. I, No. 3.

CHAPTER XV.

THE APPRECIATION OF POETRY, PICTURES AND COLOURS.

EXPERIMENTS XXXIII., XXXIV., XXXV. AND XXXVI.

The Appreciation of Poetry.—In Experiment 33 many students, especially those trained in literary criticism, will at first give records of the literary criticism type, referring to style and content. For our purpose we want to study the psychological processes more fundamentally. We definitely take up a "subjective" attitude, at least after the first free reading. Note the great individual differences. The first marked one is likely to be in reference to the relative influence of content and form. Some enjoy a poem of little content value if the sounds and rhythm are pleasing; others demand ideas of special interest. Sensivity to rhythm is, of course, a very important factor, the most important apparently with some. The main purpose of this experiment is, however, to study the influence of imagery. I give a summary of fairly extensive experiments of my own on over a hundred individuals.[1]

(1) Some persons derive their chief enjoyment of nature

[1] Described more fully in the present writer's article on "The Function of Images in the Appreciation of Poetry," *Brit. Journ. of Psych.*, Vol. XIV., Part 2.

poems from visual imagery. Some, however, can enjoy such poems without any imagery.

(2) Imagery is more likely to be a strong element in enjoyment when it (the imagery) flows along without effort; but some with facile imagery use it little in reading poetry.

(3) One type of imagery sometimes seems to displace another, the two alternating on different occasions.

(4) Dwelling on imagery is apt to emphasise one element of the poem unduly.

(5) A deliberate effort to obtain imagery is almost always injurious to enjoyment at the moment, chiefly because it interferes with rhythm.[1] But encouragement to use unsuspected powers of imagery in suitable poems increases the enjoyment of some readers. There is a danger, however, of incongruous imagery being found especially in symbolic language, as when an image of a huge heart was formed in reading Wordsworth's lines on "Westminster Bridge": "And all that mighty heart is lying still."

Experiment XXXIV.

The Appreciation of Pictures.—It is no easy matter to give an accurate introspective account of our experience in looking at a picture or reading a poem In aesthetic experiments, perhaps, above all others one cannot rely on less than (1) repeated self-observation, not only during experiments but in every-day experience; (2) the collection and comparison of records of these, especially those

[1] On this see also Dr Olive Wheeler's article, "An Analysis of Literary Appreciation of Poetry" (*Brit. Journ. of Psych.*, Vol. XIII.), which also records an important experiment on the deliberate use of imagery, on which the alternative form of Experiment 31 is partly based. For a description of an experiment on the part played by imagery in the appreciation of poetry by school children, see E. A. Peers, "Imagery in Imaginative Literature," *Journ. of Exper. Pedagogy*, Vol. II., Nos. 3 and 4,

made by persons practised in introspection; (3) the study in connection with these of the canons of art and poetry evolved by artists and poets and their critics.

The attention of the student may be called particularly to the following points:—

(1) The extent to which individual elements of the picture affect the appreciation, *e.g.* a particular colour or its placing, an interesting object of detail, etc.

(2) The effect of balance and proportion; the appreciation of unity (composition) in a wider sense.

(3) The extent to which the following affect appreciation: the thought of the artist's skill; the ideas embodied in the picture; remote associations called up by the pictures; the suggestion of sensations and feelings caused by the pictures.

(4) The extent to which the naturally unpleasant effect of something displeasing in reality (*e.g.* the depiction of suffering, hatred or anger, or an evil looking individual) is overcome by the appreciation of the excellence of its depiction in a genuine work of art.

Generally speaking the following are judgments of a low aesthetic type, and are characteristic of children: judgments based (i) on somewhat irrelevant and accidental *associations*, (ii) on the attitude to the *reality* depicted in the picture, (iii) on the interest in the *story* or idea set forth in the picture So usually are "subjective" judgments, referring to the effect on the observer himself. Of a higher type are judgments based on "expression."

Experiment XXXV.

The Appreciation of Colour.—Types of aesthetic judgment of a simpler nature may be seen in the experiments with patches of colour: (1) the subjective ("makes

me feel sad"), (2) the associative ("reminds me of a dress I like"), (3) the objective ("pure," "bright," "too thin," "dull"), and (4) the "character," probably the highest type, in which something of human character is read into colours, *e.g.* "jovial," "energetic," "sympathetic," "aggressive." These attitudes can also be traced in the judgments on pictures and on musical tones and intervals.[1]

Experiments with Children in the Appreciation of Pictures.—In aesthetic experiments with children the chief danger is suggestion by the experimenter. In asking for judgments he should purposely include poems (or pictures) which he thinks bad, and tell the children that some of the poems appear to him poor and some good.

Experiment XXXVI.

Testing Aesthetic Development.

I. *Testing Appreciation of Pictures.*

In addition to the criteria of the 'standard' order of merit of the pictures, and the appearance of 'types' of judgments, the tester should note the presence of judgments (in the A test) specially characteristic of young children. Thus:—

(1) Reference merely to individual objects in the picture; Children of from 6 or 7 to 8 or 9 usually refer entirely to the contents of the picture: "I like it because I see the flowers and the sea and the girl." The composition of the picture is at least not actually thought of.

[1] See my *Experimental Psychology of Beauty*, Chap. III., for further discussion of these types; Chap. VII. for their appearance in judgments on pictures; Chap. VIII. for their significance in music. For articles by the discoverer of these types, Mr. E. Bullough, see bibliography.

(2) Pictures with an obvious *story* are specially liked.

(3) The skill of the artist is not thought of or fully appreciated: a poorly painted picture of a handsome man is preferred to a fine portrait of an ugly man. This is true of a good many adults also.

(4) The meaning or content of the picture is felt too realistically, *e.g.* a fine picture of a storm is disliked because "It would be so cold."[1]

Professor Burt, in his test on which Experiment B is founded, based his standard order on the judgments of several competent artists, and used as many as 50 cards. Many adults did not show a very high correlation with the standard order, whereas a few of the youngest children of eight years came very near to the standard list.[2]

Another investigator used pictures of pairs of objects—chairs, teapots, jewellery; one of each pair was thought beautiful, the other inferior. She surmised that the taste of children deteriorated somewhat for several years from the age of about seven.[3]

In a recent enquiry Miss Heather Dewar found the picture test of Burt's more reliable than several other tests of aesthetic appreciation. There was evidence too of a 'general factor' involved in the appreciation, together with several specific factors, and a suggestion of different

[1] I have exemplified these various types of attitude more fully in my *Experimental Psychology of Beauty*, Chaps. VI. and VII. (At time of going to press this book is out of print, but it is hoped to publish a new edition before long.)

[2] The further results of this experiment and certain general aspects of aesthetic appreciation are admirably discussed by Burt, in Chapter XV. of the book he edited, *How the Mind Works*.

[3] See Margaret H. Bulley's "An enquiry as to Aesthetic Judgments of Children," *Brit. Journ. of Educ. Psych.*, Vol. IV., 1934, page 162, where a selection of photographs are given.

'types' of artistic appreciation, apparently related to those first described by Bullough.[1] Only a small correlation (0·22) was found between artistic appreciation and intelligence.

There is some evidence that mere repetition of good pictures increases liking for them, and preference for them.[2]

II. *Testing the Appreciation of Poetry.*

This is more complicated by vocabulary difficulties and special training in the analysis and criticism of poems. Yet even so, I have found interesting results even among graduate students. Some of the Honours students in English have put a crude and highly sentimental sonnet of Ella Wheeler Wilcox before some of the most appreciated poems of Shelley or Wordsworth.

The limits of time prevent one from using many poems, and this, of course, reduces the reliability of the test. Finally, there should be extremes of beauty and vacuity in the poems selected, and marked differences of capacity in the persons tested. For even experts differ widely in placing a set of poems of a group of our best poets. Indeed, some of our poets themselves have failed to appreciate the poetry of other great poets.

[1] See H. Dewar's "A Comparison of Tests of Artistic Appreciation," *Brit. Journ. of Educ. Psych*, Vol. VIII, 1938.

[2] See *The Experimental Psychology of Beauty*, page 89; also Littlejohns and Needham, *Training of Taste in the Arts and Crafts*, page 28.

CHAPTER XVI.

ACCURACY OF REPORT.

Experiment XXXVII.

To estimate the effect of the suggestive questions, compare the proportion of accurate to wrong answers in reply to—

(*a*) "plain" questions;

(*b*) slightly suggestive questions;

(*c*) deliberately misleading or "implicative" questions.

This experiment is really one on Suggestion, but the word was not used in the heading lest it should serve as a warning to subjects in the experiment. Yet suggestion has been found to work sometimes with students even when they know they were performing an experiment on suggestion.[1]

Children are usually much more suggestible than adults. In one group of nearly forty children, one half of them succumbed to more than one quarter of the suggestive questions. In an experiment with line-drawing, I have not found students so suggestible as children were found by Binet with his famous line-drawing experiment. In this experiment Binet presented a series of lines gradually increasing in length, which had to be drawn by the children. After a time Binet no longer increased the size of his model lines, but most of the

[1] On the general results of such experiments see Whipple, *Manual of Mental and Physical Tests.*

children went on increasing their own, some for a long time. Children indeed have been made, by plain suggestion, unable to close their hands when they tried.[1]

McDougall describes similar successful experiments with adults, who were told by a distinguished medical man that they could not move.[2]

Suggestion or Apperception.[3]—In every day conversations one may often trace the effect of a different type of "suggestion," shown *e.g.* in the mishearing of words to fit them into what the hearer expects, or to adapt them to what he knows, a point to be constantly borne in mind in teaching. Children's howlers frequently illustrate this process; for example, in answer to my daughter's question to a class of six-year-olds "What do bees do?" the reply came, "Collect *onions*, Miss." A simple experiment which illustrates how expectation can influence thought is the following, which the student can try on friends.[4] It invariably succeeds:—

A. places six pennies in his hand and shows them to *B.* Then the conversation proceeds somewhat as follows:—

A. "How many pennies have I in my hand?" *B.* "Six." *A.* "I say there are five" *B.* "I say six." *A.* "Will you give me a penny if I am wrong?" *B.* "Certainly. *A.* "Well I'm wrong: hand over the penny!"

[1] See the account of some striking experiments on suggestion made on children by F. Aveling and H. L. Hargreaves in "Suggestibility with and without Prestige in Children," *Brit. Journ. of Psych.*, Vol. XII.

[2] See *The Energies of Man*, p. 254.

[3] See footnote next page.

[4] Taken from Dr. P. B. Ballard's book, *Thought and Language*, p. 72.

CHAPTER XVII.

PERCEPTION, APPERCEPTION, AND IMAGINATION.

Experiment XXXVIII.

One main point that emerges from such experiments with the ink blots is the strong tendency often shown to read some meaning into a figure in which no meaning was intended. Sometimes this is so immediate and insistent that we must regard it as part of the process of perceiving: the blot is perceived as an insect or a tree, etc. So far as previous experience or knowledge is involved in the interpretation of the design we may conveniently use the term "apperception," though such traces of previous experience are involved in all clear perception[1] Often some interval elapses before the blot is seen as representing an object: though afterwards it may be almost impossible for the subject to get rid this interpretation.

If the suggestion is made to the subject that the next blot represents a bat or a lobster, results are so often successful that the influence of suggestion is indubitable.

Another striking thing is the great degree of individual differences. The same blot, for example, was seen by a small group of my subjects as—a kind of drill (tool), a goddess with a "Eugene Perm.," a vertebra, a Queen in

[1] For the use of the old term "apperception" see *A Manual of Psychology*, by G. F. Stout, 4th edition, revised by C. A. Mace, p. 178; or *Instinct, Intelligence and Character*, by Godfrey Thomson, p. 149.

Experiment XL.

Judgments of the Characters of Children.—This experiment, like the preceding, is based on one I carried out with several large groups of students, about 170 in all.[1] The results showed:—

1. That on the average there was very little resemblance between the judgments of the students and the estimates of the teachers on character traits: (the average of the correlations was approximately 0). As to intelligence, judgments proved only slightly more reliable. Fallible as the teacher's estimates may be, they would be nearer the truth than mere chance awards, so the students' judgments if at all reliable should have shown some approximation towards them.

2. Judgments marked as specially confident ones proved to be rather less reliable than the others!

3. The girls were more accurately judged than the boys

4. The women students and teachers were no more reliable in their judgments than the men

Miss Winifred Spielman and Professor Burt, by careful selection and special training of interviewers, by using more detailed lists of qualities, and by prolonging the interview to thirty or even forty minutes, and putting questions specially designed to reveal character, found a few interviewers who gave much more reliable results.[2] Our experiment is meant only to demonstrate the unreliability of brief interviews and impressionistic judgments of which the judger may feel most confident.

[1] See "The Relative Reliability of Men and Women in Intuitive Judgments of Character," *Brit. Journ. of Psych.*, XIX., 1929.

[2] See their article in *A Study in Vocational Guidance*, Industrial Fatigue Research Board, London, 1926.

CHAPTER XIX.

THE GROWTH OF CONCEPTS.

Experiment XLI.

I give a summary of results and observations gained in Experiment XLI. with a large class of students of advanced psychology.

(1) Most students get a working concept quickly and modify it; *e.g.*

"Batfud means a church—no—it is a building."

"Gazod = (i) "scenery especially with water"; later
(ii) "scenery, must have water; may have dogs," finally
(iii) "scenery with water."

(2) Some note a tendency first to seek the *conspicuous* element, then on second appearance to seek the *common* element.

(3) Interest in the object itself may actually divert attention from the name. "I was intent on the picture side and forgot to look at the nonsense word till about five pictures had passed."

(4) Undue haste to get the concept, by using a side or superficial association, may put one off the right tract and delay the correct apprehension.

(5) The simultaneous growth of two concepts which have something in common may result in confusion.

(6) Marked individual variations: (*a*) in speed—one student had got the right meaning for all names in the second round: in this case imagery was weak; (*b*) in type—some developed rich and highly abstract concepts, *e.g.* zavos = human beings in some relation—spiritual love: which happened to fit. Benep = some form of luxurious life. Some are exceptionally exact, *e.g.* batfud = architecture; most are content with this, but one added "suitable for institutional life," which was quite right though not intended.

It is worth considering if there is a type of mind which tends, in developing the concept, to select the minimum essential for a class of things, and another extreme type which tends to think of all common attributes. The functioning of images should be noted. Sometimes at first a nonsense word will only recall the image of a definite picture, with no meaning attached. Later a general meaning appears even if a definite image remains. Later still a meaning may occur without an image, or with varying or blurred or composite images. After two or three weeks Test (5) with A and B should be repeated, and the changes in the concepts noted.

The student should consider finally what light this experiment throws on the development of concepts in the mind of the child, and when the artificiality of the experiment would cause a divergence from such a normal development. In connection with this some reading should be done on the psychology of concepts and the use of language in their development.[1]

[1] For a thorough discussion of the growth of the concept, the student is referred to Dr. Aveling's book, *The Consciousness of the Universal*, in which is described a very full investigation on which this experiment is based.

Inductive and Deductive Method of Teaching Concepts.—To the student of education perhaps the greatest value of this experiment will be to illustrate the difficulties and dangers of building up a concept by unaided inductive methods. How much more quickly would adult students have learnt the true definition of those nonsense words if the definitions had been dictated. The superiority of a mixed method to purely inductive or deductive has been illustrated by an experiment with grammatical terms, among children about ten years of age.[1]

Obviously much will depend (*a*) on the age of the pupils, and (*b*) on the nature of the concepts and their familiarity. Concrete examples are needed, especially for new and unfamiliar material, and with young children who find a general definition difficult to grasp.

[1] See H. L. Fowler, "The Development of Concepts," *Brit. Journ. of Educational Psych.*, Vol. I., p. 13, 1931.

CHAPTER XX.

THOUGHT PROCESSES.

Experiment XLII.

Restricted Associations.—In some cases the student will probably find that he can give no account of the mental process which has taken place in this experiment. The response seems to come instantaneously and automatically. The instruction to give a part of the whole mentioned, may itself be apparently forgotten, *i.e.* it is not consciously thought of before reaction, especially after some practice. This is, in itself, very significant, and introduces us to one of the most important facts about more complex thought processes. For we see that, as the instructions are obeyed, they must continue to function even if not present in consciousness. The most we can say is that the instruction causes a certain *mental attitude*, and that this attitude persists even when the words of the instruction are no longer in consciousness.

The determination of the way in which a word is apprehended (*e.g.* as a whole with parts) is an example of "apperception." Thought processes, however, are exceedingly elusive, and it is fairly certain that at first some elements of the processes are not discriminated by the student. It is a useful exercise to devise and perform experiments similar to these after this chapter and others on the psychology of thought have been read.

The instantaneous automatic replies in the part-whole, genus-species, species-genus, and opposites tests naturally occur most frequently with pairs of words which are habitually thought of as pairs: *e.g.* the contrasts good-bad, light-dark, are constantly in mind. Less common words have been arranged towards the end of each series; the stop-watch will probably indicate that the reaction here was more prolonged—and the student should have more introspective material to give.

In the whole-part experiment in a large class the reaction time, roughly estimated by the counting method, varied from $\frac{3}{5}$ to $\frac{32}{5}$ secs. Often visualising helped. By two-thirds of a class of fifty, an image was definitely called up to help when the process did not take place readily,[1] at other times imagery hindered; sometimes an image had to be banished before the thought process could be proceeded with.

The instruction (whole-part) was sometimes quite forgotten and some association given in response, not a word indicating a part of the given whole. With others the instruction remained in consciousness throughout, and if forgotten once was apt to cease to function. With others the instruction was not traceable as a conscious element, yet continued to function, for the responses were correct.

Delays were repeatedly due to (i) conflicting associations (*e.g.* words in frequent association like chair-table), (ii) unhelpful visual imagery, (iii) multiplicity of choice (*e.g.* the many different kinds of "parts" of a University), (iv) persistent auditory image of the stimulus word.

Most of these points appear in a similar way in the species-genus, opposites, and analogies experiments.

[1] Cf. C. Fox: "The Conditions which arouse Mental Images in Thought," *Brit. Jour. of Psych.*, Vol. VI., p. 420.

Experiment XLIII.

Analogies and other Relationships.—The ready perception of analogies is a very important factor in thought processes.[1] The analogy experiment constitutes one of the most useful mental tests now in use, and the experiment should give the student some insight into the mental processes involved in such a test. In (*a*) the two first terms given show the relationship, and the third term is given. In (*b*) 1 and 2, and 3 the relationship is set by the two first terms, but two terms with a corresponding relation have to be found. In 4 and 5 the terms have to be found within a given limited sphere (politicians and authors). In (*c*) there are various determinations and more complicated relationships. Students find it difficult to give much in the way of introspective records of thought processes in such cases. Indeed, the experiments are included partly with a view to showing the elusiveness of thought (for something happens even when we cannot detect its nature), and partly with a view to familiarising the student with such abstract forms of relationships, so that he may be on the look out for them and study their functioning in every-day thought and reasoning.

Facility in apprehending relationships and in supplying parallel examples (in other universes of thought, perhaps) is undoubtedly a valuable capacity. There are great individual variations in this respect. Genius of certain types partly consists in a great capacity for perceiving unusual relationships. The relationship aspect is abstracted and applied in varied fields. Note also how

[1] Cf. the important place given to the "Eduction of Correlates" as a main factor in new cognitive processes, by Professor Spearman, in his book, *The Nature of Intelligence and the Principles of Cognition.*

far this capacity seems to be specific. How far does the science student tend to fill in scientific examples, and the mathematical student mathematical ones? Do ideas of certain kinds of relations function more readily than others in a given individual? The perception of relationships will arise again in connection with Intelligence Tests.

Experiment XLIV.

Problems in Reasoning.—In these problems note:—

(i) The extent to which imagery is helpful or harmful. Mr. C. Fox in the research already referred to (p. 237) found that a conflict in thought tended to rouse relevant imagery.

In an experiment with Problem v. (on the value of international congresses) I suspected that vivid visual imagery tended to produce a hurried judgment, only one aspect being presented, and that forcibly.

(ii) The extent to which the conclusion seems to be reached almost automatically—the words being treated almost as counters: *e g.* equals plus unequals giving necessarily unequals—without getting beyond the words.

(iii) The dependence in the longer problems on span of apprehension and "immediate memory for significant verbal material"; note especially Problem iii.

(iv) The dependence on the width of field of attention—the grasping of all relevant points as a unity. This is where children often fail.[1] Note especially Problem iv.

(v) The necessity for selection of essential points and the dropping of the unessential out of mind. Note especially Problem iv.

(vi) The influence (*a*) of interest in urging continuity of thought towards the solving of the problem, and (*b*) of caution in checking too hasty a solution.

[1] See C. Burt: "The Development of Reasoning in School Children," Part II., *Jour. of Exper. Pedagogy*, Vol. V.

CHAPTER XXI

GENERAL INTELLIGENCE TESTS.

Experiment XLV

The Nature and Purpose of Intelligence Tests.—The aim of intelligence tests is to provide a measure of inborn intelligence, as far as possible independent of special advantages or disadvantages in education and environment. Complete independence of training can never be reached; but it is claimed for good tests that they only need such training and experience as any normal child of a given age can be assumed to have had. Thus most tests for twelve year olds involve the capacity to read and write simple material; but it is argued that every child of twelve, if not mentally defective, has had sufficient training to enable him to do this with ease: and that differences in results depend on other factors involved, such as the intelligence required in solving some problem for which special knowledge is not required, the difference between the results gained by one child and another being attributable to the varying degrees of intelligence with which they have taken advantage of such experience.

Some of our tests indeed, such as the spot pattern test and the maze test, involve no reading or writing, and there are now many 'performance' tests which involve no reading or writing, but they do not correlate so highly with general ability as do tests of higher processes, such as

reasoning. There is evidence too that specialised linguistic ability and training is not of great importance in determining success in many of the other most reliable tests. It can scarcely be doubted, however, that in such a test as the completion test special linguistic training would be of some value.

Further, it must be remembered that reliance is not placed upon any one test alone. A group of tests differing in nature is used, and the more varied the group the less likely is the average result to depend on special abilities or specialised training, and the more likely to depend on some common factor or factors of what we vaguely call general intelligence.

What is General Intelligence?—This is not the place to discuss in detail what is or should be signified by the term "general intelligence." In the first edition of this book (1914) it was suggested that a scientific psychology would have no use for this term. Certainly it is used in different senses by psychologists themselves. Whether there is one mental element, and one only, which is the supremely important factor in all activities involving intelligence, is still a matter of dispute. Spearman maintains there is such a single general factor, but he refuses to call it intelligence, and denotes it simply by "g." This general factor he holds is a species of mental energy. In all cognitive activities this "g" is involved, and so are certain specific factors, abilities specific to each kind of mental activity.

It seems clear now that there are also a number of important "group factors"—that is an element which enters into a considerable number of mental activities differing in some respects. The following are among such group factors:—Linguistic ability, a verbal and other

memory factors, arithmetical ability, mechanical ability, musical ability, "social" factors, etc.

Spearman finds "g" especially important in those tests which even psychologists who do not agree with him regard as the best tests of general intelligence:—*e.g.* reasoning, completion tests, analogies, etc.; all in fact which involves the grasping of "relations."

Thus for practical purposes it is fortunately not necessary to agree on a precise definition of general intelligence; as Burt has said, Spearman's theory of one general factor makes a useful working hypothesis.

Even Spearman's chief critic, Professor Godfrey Thomson, a leading authority on intelligence tests, while maintaining that we have as yet no proof of the existence of one general factor, admits that the facts are consistent with that view; and more important for our present purpose, the kind of tests he uses are largely the same as those used by Burt and Spearman,[1]

The Finding and Testing of Tests.—The selection of tests may be approached in several ways:—

(i) We may devise tests which seem clearly to involve intelligence and little or no training (*e.g.* reasoning), and then find which of them correlate highly with the general intelligence of pupils as estimated by those who know them well.

(ii) We may devise tests of all kinds of mental activities, and then find which of them correlate most

[1] On the subject of general intelligence and its relationship to tests see:—R. Knight's excellent introduction, *Intelligence and Intelligence Tests*, and Godfrey Thomson's lucid exposition in his *Instinct, Intelligence and Character*. Very comprehensive works are Spearman's *Abilities of Man* and Burt's *Mental and Scholastic Tests*.

highly with the others, which are at the top of the "hierarchy" of correlations, and involve most "g."[1]

There are two other tests of tests which must be used with care:—

(i) We may compare the performances of children of various ages. If, as is generally agreed, intelligence grows with the age of the child, then the scores in a test should be higher for each successive age group, up to the limit of growth of innate ability, which is now thought to be about 16 or 18, or perhaps more for higher intelligence. But the mere fact of better performance in a test at 11 years than at 10 is no proof of its validity as a test of innate intelligence, as the improvement may be largely due to training, *e.g.* in spelling or in dealing with numbers. Furthermore, within a given school class, where the pupils are about the same level in school work but of different ages, a good intelligence test should give a *negative* correlation with age.

(ii) A useful check on the validity of a test is to compare the performances of a bright young class with an older but decidedly duller class.

Completion Test.—The following is the passage printed in full, of which portions were used for a completion test A in Experiment XLV.

PIECE A.

"About three-fourths of the whole population of England belong to the wage-earning classes; and at all events when they are well fed, properly housed and educated, they have their fair share of that nervous energy which is

[1] For the mathematical calculation of the extent to which various tests involves "g" see Spearman's *Abilities of Man* or F. C. Thomas, *Ability and Knowledge.*

the raw material of business ability. Without going out of their way they are all consciously or unconsciously competitors for posts of business command. The ordinary workman, if he shows ability, generally becomes a foreman: from that he may rise to be a manager, and to be taken into partnership with his employer. Or, having saved a little of his own, he may start one of those small shops which still can hold their own in a working man's quarter, stock it chiefly on credit, and let his wife attend to it by day, while he gives his evenings to it. In these or in other ways he may increase his capital till he can start a small workshop or factory. Once having made a good beginning, he will find the banks eager to give him generous credit."[1]

Piece B.

CONJUNCTION-COMPLETION TEST.

This is a test I devised especially for adults. Even some highly intelligent persons, including many University graduates, fail at certain points in this test.

The following are the words most suitable for the numbered spaces. A synonym may, of course, be used.

(1) therefore *or* thus, (2) indeed, (3) even, (4) moreover *or* even, (5) for, (6) since, (7) for, (8) yet, (9) for, (10) now, (11) even, (12) consequently.

Note how different fine shades of meaning and relationship are brought out by different words. Ready apprehension of relationships of this kind is an important factor in continuous reasoned thought. Observation of the lax way in which even University graduates used such conjunctive words as "thus," "for example," etc. led me to devise a test in which the missing words were confined to conjunctions.

[1] From Alfred Marshall, *Economics of Industry*.

A graded series of sentences and short paragraphs which I made on the same method has proved useful with children. Thus:—

Fill the blanks in the sentences below with the connecting word which makes the best sense. *Do not use "and."*

(1) I love my father he sometimes punishes me.

(2) My father is wiser than I am; I shall follow his advice.

(3) John ought to take care of his brother Cecil Cecil is so much younger than John.

(4) John is much older than Cecil he never takes proper care of him when they go out together.

(5) Mary is most helpful in the house; this morning she lit the fire before her mother came down

(6) The teacher will give John Jones a prize he is the first boy in all the subjects in the class; he has set a splendid example by his good conduct.

(7) The captain of the ship stayed on deck to the end the ship was sinking he had a wife and three children at home. (One child filled in the first blank correctly with "when" and the second with "*because*"!

A series of such a type would seem to supply a useful test of what Professor Spearman calls the "eduction of relations."

Experiment XLVI.

This is given as an example of a non-verbal test. The quickness of grouping visual impressions is an important factor. Careful introspective records should be made of the processes involved as practice brings improvement.

If the influence of any element of "general intelligence" seems slight we should nevertheless bear in mind the high correlation with estimated intelligence that has been

obtained with the test, in the experiment referred to (on p. 126), though the card dealing then involved may have helped to increase the correlation. Spearman's conception of 'g' as a general fund of energy makes the correlation of such tests with estimated intelligence more comprehensible.

Experiment XLVII.

Experiment XLVII, *a*, *b*, *and c* are also given to exemplify non-verbal tests. In test XLVII., (*a*) a specific (or group) ability in the grasp of the relation between numbers is no doubt involved.

In (*b*) note the qualities of character needed for success: restraint of the impulse to rush on, the careful exploration before starting, pausing at times to test for blind alleys. The Porteus maze test series has been found to correlate to the extent of about 0·6 with a Social Ratings scale (including planning ability, suggestibility, impulsiveness), etc. The series of maze tests also correlated with 'Industrial Ability' about 0·7 against the Binet test's 0·64.[1]

In (*c*) the student should note how intelligence may compensate for poor memory. Of course no inference can be made as to the relative capacity of subjects with this test, as slight variations in the cutting of pieces may make great differences in difficulty; the purpose is to provide means of studying the processes involved. In any case we have no proof so far that even a group of such intelligence tests will grade a fairly homogenous group of intelligent adults in order of general intelligence. Also some persons are affected much more than others by time limits.

[1] See S. D. Porteus, *The Maze Test and Mental Differences*, p. 88-9.

Experiments XLVII. (*c*) and (*d*) are suggested to give the student some idea of the confusing effect of working such tests at speed, and yet of the valuable mental quality that enables a man to keep calm and steady in such work and not to be rushed to decisions without reflection. The effect of making a test a "speed" test as compared with giving unlimited time, seems to vary considerably according to the nature of the test. The speed with which higher mental processes take place is closely related to capacity. In motor and reproductive processes there is a speed factor which seems independent of the general factor. In some of the best group tests in common use, a close correlation has been found between (*a*) performance at speed, and (*b*) performance with no time limit. This, however, is consistent with a few persons being greatly affected by a speed test, as I have found in my own experience with adults.[1]

In addition to these tests given in this chapter, tests similar to the reasoning problems in the previous chapter have frequently been used as intelligence tests, and all have given high correlations with "estimated general intelligence."

Others giving lower correlations are: Whole-Part, Species-Genus or Genus-Species Tests, and Mirror Drawing.

[1] On the aspect of speed and its relation to a general factor in intelligence, see Spearman's *Abilities of Man*, Chap. XIV., and his *Psychology Down the Ages*, Vol. II., p. 258 and elsewhere: also R. B. Cattell, *A Guide to Mental Testing*, p. 5; R. Knight, *Intelligence and Intelligence Tests*, pp. 62-63; and G. M. Ruch and W. Koerth, "Power versus Speed (in Army Alpha Tests)" *Journ. of Educational Psych.*, April 1923 (summarised in *Forum of Education*, Vol. I., No. 2).

Intelligence Tests compared with Examinations.—(i) *Intelligence tests estimate "native" capacity rather than acquired knowledge.* The most evident difference between such tests and examinations lies in the fact that special preparation in the subject of the examination is so important a factor in determining success. The length of time the child has studied the subject, and the quality of the teaching which he has had, help to determine the result of an examination, so that this result does not depend merely upon his own congenital capacity.

The particular kind of education the child has had does not, however, affect nearly so much the results of such a test as mirror drawing or the reasoning tests. Thus we could apply them more fairly to children whose training had been very different. They have, for example, been used to compare the general intelligence of children at a Preparatory school with that of children at an Elementary school.

Opinions seem to differ as to whether two such groups of children would differ greatly as regards *native* intelligence. Obviously it would be unfair to attempt to decide this by means of examinations in school subjects, for the children of a Preparatory school will have had much better training in certain subjects though the Elementary school children may have concentrated more thoroughly upon others. We should be at a loss to know whether we should attribute a better performance in, say, arithmetic on the part of one of these groups of children to a more efficient or prolonged training in the subject or to superior natural capacity. But such tests as reasoning, apprehension of numbers, and other tests do not suffer from such limitations.

Of course, from another point of view, examinations are superior to simpler mental tests. This is due to the very fact

that examinations are means of estimating not merely native ability but also previous training and application. Thus they are tests of the amount of good work done, and often of the presence or absence of some valuable moral qualities which have little or nothing to do with success in psychological tests. On the other hand, success in some examinations may be due to special and narrow cramming.

(ii) *Intelligence tests can be kept more constant in difficulty and can be more exactly marked than is the case with examinations.* Thus they can be more easily standardised, and the results given by children in different schools and even in different countries can be compared.

All who have had any experience in examining know how difficult it is to set two examination papers of exactly equal difficulty. Further, it is often difficult to maintain the same standard throughout in marking the answers of the same examination paper. When different examiners set and mark different papers in different schools, or in the same school at different times, still greater divergence of standards is likely to result. With intelligence tests, however, a more constant standard can be maintained and exact marking is easier. Thus one experimenter can apply certain tests to children in England, and another experimenter can apply the same tests, in the same manner, allowing the same length of time, to children in America, and the results may be fairly compared.

It must be admitted that the difficulty of maintaining a constant standard in examinations would be greatly reduced if the methods suggested by Dr. Ballard in his *New Examiner* were adopted. Following the plan of some mental tests, he advocates the use of many short questions requiring only one or two words in answer. This, however, would give no scope to the more

constructive work (involved, for example, in essays), though the same criticism can be applied to many mental tests.

Examples of the Application of Intelligence Tests.—(*a*) Intelligence tests have been applied with success in the differentiation of defective and normal children.[1] By standardising tests for a given age, and finding which age test a given child just passes, we have a convenient means of indicating approximately his mental level; thus, if a child of eight only passes the six-year-old tests his "mental age" is said to be six.

(*b*) Tests have been used further to estimate the comparative intelligence of the sexes,[2] a problem obviously difficult of solution by ordinary examination methods owing to differences of previous training; for even when boys and girls are educated in the same school, the influence of home, of friends, and of the general traditions of the sexes, and the divergence of future purposes and aims, greatly affect the attitude of boys and girls to the respective school subjects. Further, success in school work depends not merely upon intellectual capacity, but also upon such qualities as ambition and conscientiousness.

So far it has been found that on the average there is little difference between boys' and girls' performances in the tests of higher capacities. But it should be noted that these tests are rarely of a very prolonged type, involving great continuity of effort.

[1] See especially Dr. Burt's comprehensive work *Mental and Scholastic Tests.*

[2] A pioneer study of this problem was "The Mental Differences between the Sexes," by C. Burt and R. C. Moore, *Journ. of Exper. Pedagogy*, Vol. I.

(*c*) Intelligence tests have also been applied to the problem of the hereditary transmission of intelligence. In the very interesting experiments upon Preparatory and Elementary school children already mentioned, it was found that, in all the tests which correlated with general intelligence, the Preparatory school boys were superior to the boys of the Elementary school, The only two tests in which the Elementary school boys were equal or superior to the others were tests which gave *negative* correlations with intelligence, *i.e.* in which duller boys of each school did better than the more intelligent boys of the same school.[1]

More recently several extensive researches have been made among the children of parents at different economic levels. They reveal a decided tendency for the *average* intelligence to decline with the drop in the economic scale. The birth-rate is also highest in the families with the least intelligent children, which constitutes a serious eugenic problem.[2]

(*d*) Intelligence tests are now used in many centres to select pupils from elementary schools for free places and scholarships in secondary schools, in order to avoid unfairness due to some pupils having had special coaching or better teaching than others. Further, the very excellence of the plan of work in one school may result in

[1] See C. Burt, "Experimental Tests of General Intelligence," *Brit. Journ. of Psych.*, Vol. III.

[2] See C. Burt, *Mental and Scholastic Tests*, p. 191; D. C. Jones and A. M. Carr-Saunders, "The Relation between Intelligence and Social Status among Orphan Children," *Brit. Journ. of Psych.*, XVII, 1927; R. B. Catell, *The Fight for our National Intelligence.* A general review of recent work on the subject is given by E. J. G. Bradford, "The Relation of Intelligence to Varying Birth-rate in Different Social Grades, *Brit. Journ. of Educ. Psych.*, VII., 1937.

poor examination results at eleven years of age, if the questions are of a bad type. Enquiry has shown that some of these entrance examinations are most unreliable,[1] and among the best it is found that intelligence tests alone give as good a prophecy of success in the Secondary school as do the combined papers in English and arithmetic.

(*e*) Intelligence tests are regularly used for purposes of vocational guidance. Of course, tests of specific abilities, and estimates of interests, disposition and character may be even more important; but it has been found that for certain occupations, intelligence below a corresponding level is unsatisfactory, while on the other hand a youth may be too intelligent to work contentedly in some occupations.[2]

(*f*) Intelligence tests may be used to reveal a different average of native abilities in different schools or in different districts. Similar results tend to be expected by parents and inspectors in all schools of the same type, which is unfair to teachers in schools having children of a lower average ability.

Professor Godfrey Thomson found some interesting differences among schools in various districts in Northumberland. High ability was frequently found in well-to-do suburbs in Newcastle, while the highest percentage

[1] See *The Reliability of Examinations: an Enquiry*, by C. W. Valentine, with the collaboration of W. G. Emmett. A scheme whereby this examination could be abolished and Free Places, etc. awarded on the basis of intelligence tests and reports of the Heads of the Primary schools, is advocated in the present writer's pamphlet, *Examinations and the Examinee*. (Birmingham Printers, 1938).

[2] Dr. A. Macrae's book, *Talents and Temperaments*, admirably treats the connection between intelligence tests, special abilities and vocational guidance. Reference should also be made to the publications of the National Institute of Industrial Psychology, especially their Report (No. 5) on Research Work.

of very able pupils was found in the remote valley of the Cheviots The suggestion made was that these latter parts had not been drained of their ablest inhabitants by migration to the city as had those parts nearer Newcastle.[1]

(*g*) Intelligence tests were used with remarkable success in the United States army during the Great War. It was found, for example, that a fairly reliable prophecy could be obtained as to a man's performance if promoted to be a non-commissioned officer, on the basis of a series of group tests[2]

(*h*) Tests have yet to be applied with equal success to higher degrees of intelligence among adults, though several Universities and Colleges in America and in England have found it useful to apply supplementary tests to new entrants.[3]

Criticism of Intelligence Tests.—It is significant of the great change which has taken place in the attitude towards intelligence tests in recent years that the author has felt able to omit practically the whole section which appeared under this heading in the earlier editions of this book.

The limitations of general intelligence tests—for example, the need for tests of special abilities and the importance of interests and character qualities not involved in intelligence tests, are fully recognised by competent psychologists and are tested in other ways. Criticisms of the tests are now largely confined to those who know very little

[1] See Godfrey Thomson, "The Northumberland Tests," *Brit. Journ. of Psych.*, Vol. XIII., 1.

[2] See *Mental Tests in the American Army*, by C. S. Yoakum and R. M. Yerkes. (London: Sidgewick and Jackson, 1920.)

[3] Tests are regarded now as an "indispensable" criterion for admission to Columbia University. See R. Pintner, *Intelligence Testing*, p. 276. See also references in Bibliography.

about them, or have come across cases in which some intelligent adult failed in some intelligence test, even one intended for children. Such critics ignore the fact that for the estimation of intelligence no competent psychologist would rely on one or two tests, but would require half-a-dozen or even a dozen tests, each of which may include a score or even a hundred separate items It is possible a clever person may fail in one particular item, but he cannot do badly on the average performance of a large number of items. Furthermore, too often intelligence tests are judged by what are mere jokes or catches published in the popular press as intelligence tests.

One criticism, however, must still be treated seriously, namely that it is possible to coach children in intelligence tests. For this reason tests are constantly being altered and no group of children would be tested by identically the same tests twice, except for research purposes. Experiment, however, has shown that the effect of special coaching can be largely counteracted by the giving of a little coaching in the test itself by the tester just before the actual test is applied: for example, by explaining the analogies test to children and practising them for a few moments in the test, the effects of previous special coaching of a few of the children are practically nullified.

One other criticism must also be treated seriously, namely, that the child may vary in its general form day to day. It has indeed been found that there are considerable fluctuations of this kind, and for a sound estimate of the intelligence of the child, or the adult, it is desirable to give a series of three or more tests separated by intervals of a few weeks.[1]

[1] See A. G. Rodger. "The Application of Six Group Intelligence Tests to the Same Children and the Effect of Practice," *Brit. Journ. of Educational Psych.*, VI., 1936.

The Binet-Simon Tests of General Intelligence.—A chapter on Intelligent Tests would not be complete without a reference to the Binet tests, though those already dealt with yield higher correlations with estimated intelligence and depend more upon a general innate ability than do the Binet tests, with normal children above the age of eight or nine. The Binet Tests contain a number of items, success in which depends too much upon training or environment. Among groups of children with similar home and school environment, however, they provide a handy means of getting a rapid, if not very exact estimate of a child's intelligence as compared with his fellows, and especially of children on the border line of mental defect. Originally devised for French children, they have been adapted and developed, especially by Professor Burt and Professor Terman.[1] In the first edition of this book I gave an arrangement of the tests based on an examination of researches then extant. In the present list I have made some further adjustments, chiefly because of Dr. Burt's extensive enquiries

The tests are given for the years from four to nine, as these are the years for which the group tests are rarely suitable, and also they are the years at which rapid estimations of the general intelligence of children are frequently likely to be needed; for example, when the children are beginning their school life or entering a new school.

One of the chief values further lies, not so much in the actual scores, but in the insight gained into the minds of the children tested, shown especially by the manner in which

[1] Prof. Terman, with Miss M. A. Merrill, has recently published an extension of the tests, giving a double set of tests for each age: but these have not yet been standardised for English children. See their book, *Measuring Intelligence.*

they tackle the problems. In fact, one combines the advantages of the "interview" with those of the mental test.

The tests are included here chiefly because individual tests of this type form the best medium for the first training of the student in testing.

In applying the tests it is of the utmost importance not to make the slightest suggestion to the child. Individual variations in the mode of putting the tests, especially among untrained teachers, make one set of results hardly comparable with others. But this does not affect the comparison of different children by one experimenter on the basis of his own results.

Binet's Intelligence Tests.[1]

Four Years of Age.—(1) Say a simple sentence of six syllables and ask the child to repeat it: *e.g.* "I am cold and hungry."

(2) Ask the child to repeat after you, (i) 639, (2) 592. Pronounce the figures slowly. One attempt out of three must succeed.

(3) Put four coins on the table and ask the child to count them.

(4) Draw a line of 5 cm. and one of 6 cm. parallel to one another, about 3 cm. apart, and say to the child, "Tell me which is the longer of these two lines."

One investigator suggests that we should say "longest," this being what the child would probably say himself.

(5) "Which of these two is the prettier?" Three pairs of drawings such as those given in Fig. 14 are to be used. Show them one pair at a time and do not point to

[1] My thanks are due to Dr. Th. Simon for permission to reproduce copies of the pictures and diagrams.

either face. All three must be chosen correctly at first attempt.

Five Years of Age.—(1) Draw a square about an inch long and ask the child to copy it, with pen and ink. Let him make three copies. Two at least should be free from bad curves and overlapping ends. Thus A, B, and C should be rejected, but D and E passed. (See Fig. 13.)

(2) "Which of these two boxes is the heavier?" Small boxes of the same shape and size, but containing different quantities of shot and other material, should be used, The weight of the pairs should be as follows:—

3 grams and 12 grams.[1]
6 grams and 15 grams.

Place a pair of the boxes about three inches apart on a

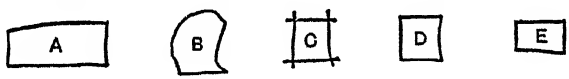


Fig. 13.

table in front of the child. The main point here is to note, whether the child knows how to set about estimating and comparing weights.

(3) "Is it morning or afternoon?"

(4) Repeat a sentence of twelve syllables. Three chances should be given if necessary, with a new sentence each time.

Suggested examples: "If you go out be sure to take your heavy coat." "When Spring comes the little birds will sing in the trees."

(5) Say to the child, "Here is a key I want you to put it on that chair. Then shut the door. Then on the chair near the door you will see a box. Bring me that

[1] 1 gram = 15·4 grains, approximately.

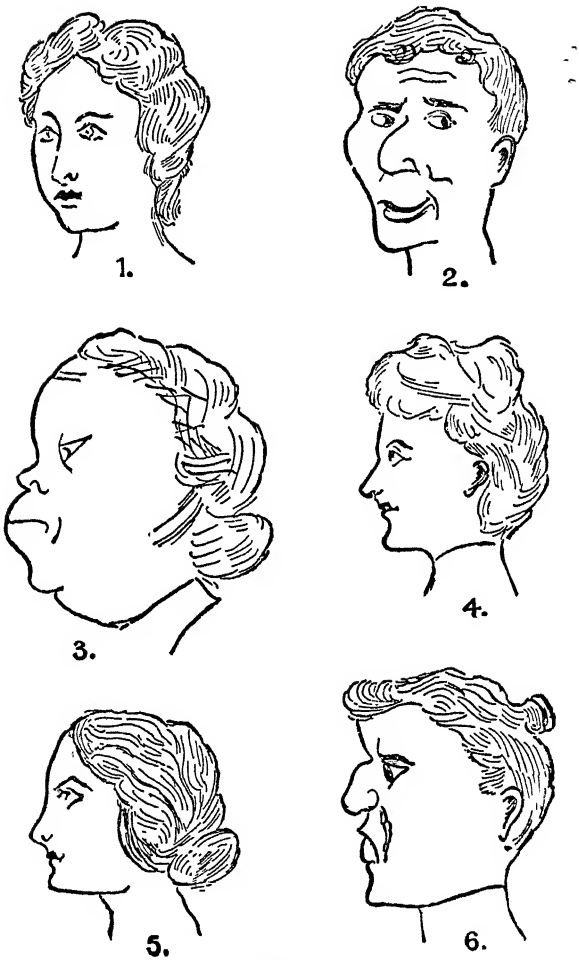


Fig. 14.

box. Now listen again . . . first put the key on this chair, then shut the door, then bring me the box." All three orders must be executed and in the correct order. This is a test in which much will evidently depend on the clearness of the directions.

(6) "What colour is this?" Show red, yellow, blue, and green. No failure must be allowed.

Six Years of Age.—(1) Procure two oblong pieces of cardboard of equal size. Cut one oblong diagonally. Place the two triangles thus obtained near the other oblong on the table thus:

Fig. 15.

Say, "Put these two cards together," pointing to the triangles, "so that they make a figure like this," pointing to the oblong.[1]

(2) "Show me your right hand." "Show me your left ear."

Binet found that practically every four-year-old child pointed to his right ear after having pointed to his right hand, while one in three of the five-year-olds made a mistake.

[1] Two investigators put this test at four years; Burt with Binet at six years; two others, including Terman and Merrill, put it at five years. A good deal depends on the way in which the triangles are placed. When placed as in Fig. 15 one triangle has to be turned over to accomplish the test.

(3) "What is (i) a fork, (ii) a table, (iii) a chair, (iv) a horse?" Definition by usage should be possible at this age, *e g.* a fork is to eat with; a chair is to sit on. At a later stage definition by classification and by enumeration of qualities begins. Younger children are frequently content with the repetition of the word, thus "What is a fork?" "A fork." At least three definitions out of five should give something more than this.

(4) The child should repeat a sentence of sixteen syllables. One out of three sentences to be repeated correctly.

(5) Place thirteen pennies before the child and ask him to count them aloud, and to point to each penny as he counts it. No error should be made.

(6) The child is required to copy accurately with pen and ink a diamond shape. Binet accepted figures 1, 2, and 3 below, but not figures 4, 5, and 6. (See Figure 16).

Seven Years of Age.—(1) Comparison from memory. "You know what a fly is?" "Yes." "And you know what a butterfly is?" "Yes." "Are they the same?" "No." "Well, what is the difference between them? How can you tell them apart?" There should be real comparison in at least two out of three pairs of objects suggested. The two objects for comparison must be quite familiar to the child. Other pairs suggested: milk and water, cloth and paper.

(2) Place three pennies and three halfpennies on the table. Say to the child, "Suppose I were to give you all these how much would you have in halfpence altogether?"

(3) "Look at this face. What is left out?" The test is passed if two out of three are done correctly. (Fig. 17.)

(4) "I am going to say three numbers. I want you to say them *backwards*: for example, if I say 274 you must

say 472." Give three sets if necessary. One correct scores a pass.

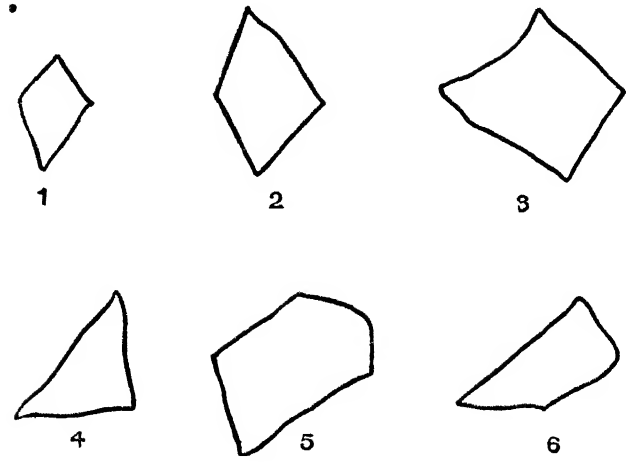


Fig. 16.

Eight Years of Age.—(1) Easy problem questions.
(i) "What should you do when you miss a train?"

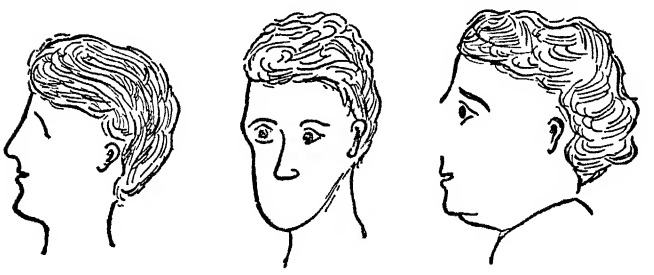


Fig. 17.

Good answer, "Take the next." Bad answers, "Run after it," "Go home," "Buy a ticket."

(ii) "What should you do when you break something which does not belong to you?"

(iii) "What should you do if a boy you are playing with hits you without meaning to?"

Two sensible answers may be regarded as satisfactory.

(2) "Count from twenty backwards to nought." If necessary start the child with 20, 19, 18.

The counting should be completed within twenty seconds.

(3) Ask the child (i) the day of the week, (ii) the month, (iii) the day of the month, (iv) the year. Allow an error of three days either way in the day of the month. Pass if three out of the four items correct. Special teaching will obviously affect this test; but some younger children tested by Binet had actually been especially trained by daily practice in giving such dates and days, yet failed utterly in this test, showing, Binet argued, the uselessness of premature instruction.

(4) Ask for definitions of common objects, as in question 3 for six-year-olds. By now the children should give something more than mere usage; *e.g.* instead of saying that a horse is "for drawing carriages," the classification of horse under animal may be given thus: "a horse is an animal that draws carriages," or a description may be given. At least two out of five definitions should include something more than usage.

Nine Years of Age.—(1) Ask the child to read the following sentences, and after two seconds pause, say "Tell me what you have been reading about: tell me as much as you can." Help may be given in reading three or four of the most difficult words. Each main word or idea recalled scores as one item. Six items should be recalled (two by eight-year-olds). The lines indicate unit items.

THREE | HOUSES | ON FIRE
London | September | 5th |

A big | (fire) last night | burnt down (three) houses | in the middle of the city. | Seventeen families | now have no homes. | (The loss is more than) 150,000 pounds. | A young barber, | who saved | a baby | in its cradle | was badly | hurt | about the hands.

(2) Repeats six figures once out of two trials: *e.g.* 792356.

(3) "Tell me the names of all the months in order." One error or omission or misplacement may be allowed.

(4) Place on the table, in haphazard order, a halfpenny, penny, sixpence, shilling, florin, half-a-crown. Ask the child to name these. A second trial may be allowed.

The Method of Using and Scoring.—Suppose it is desired to test a child of six years of age. The investigator should first apply the tests prescribed for children five years of age. Success in these will give the child confidence. If he fails to pass the test, *i.e.* answer less than all of the five questions, the tests for children still a year younger should be applied.

Suppose, however, the child passes the five-year-old test satisfactorily, he should proceed to the six-year-old test. If this is passed, or if any question in this is answered correctly, the test for seven-year-olds should be used, and so on until a test is reached in which the child answers none of the questions for that year.

Even the child who has failed in the five-year-old test and who had to go back to the four-year-old test should subsequently be given the six-year-old test, then the seven-year-old test, and so on, until a test is reached in which the child answers none of the five questions.

If a child of five passes the test for five-year-olds and also the test for six-year-olds, his "mental age" is said to be six years, *i.e.* he is a year ahead of the average.

Failure in any individual question may be compensated for by passing any question for a later age. Thus one failure in an 8 years question, but three questions done in the 9 years test would give a mental age of $8 + \frac{3}{4} = 8\frac{1}{2}$ years.

Further, additional mental age is added for questions done beyond the age for which the whole of the questions are done. Thus, four questions done in the tests for 7 years and 8 years, in addition to all the 6 year questions, gives a mental age of $6 + 1$ years.

Intelligence Quotient.—The ratio of a child's mental age to his actual age gives his "intelligence quotient" or "mental ratio." This usually remains fairly constant at different ages up to the limit of maturing of intelligence.[1] There are, however, many exceptions and fluctuations, but some of these are no doubt due to temporary variations in efficiency of the kind already referred to, while others may be due to variations in the relative difficulty of the different tests used for the same child at different ages.

[1] Some authorities think that innate general ability is fully matured in most individuals by the age of about 16 to 18 years, later perhaps for the ablest and earlier for the dull. The question, however, cannot be regarded as definitely settled as yet.

CHAPTER XXII.

TESTS OF MANUAL DEXTERITY.

Experiments XLVIII., L., LI., LII. and LIII

Some performance tests (*e.g.* the Porteus Maze Tests and the Form Board) have been devised in order to get rid of the effects of special linguistic ability or training when testing intelligence. Those described in this chapter, however, are not suggested as general intelligence tests, but as tests of fairly specific motor capacities, though one point the student should note is how far intelligent thought can help in the tests.

B. Muscio, in some experiments, chiefly on children, with similar tests (but including Tapping and Tracing), found little or no correlation between the results of the various tests, and hence inferred that there was no common factor involved, and, therefore, that intelligence could not be involved; and also that there is no such thing as "general motor dexterity" or "practical ability." In some similar tests with a small group of adults, however, the present writer got correlations between the various tests of from ·23 to ·4. One woman (a gymnastic mistress) was at the top of each test, one man at the bottom of each.

On a far wider series of tests Burt found that, even when the intelligence factor had been ruled out, a common manual factor revealed itself in more complex manual work, *e.g.* handwork, drawing, and writing.[1] The most

[1] See his report *The Distribution and Relations of Educational Abilities* (1917).

recent work on the subject indicates the existence of (*a*) a constructive manual ability, and (*b*) manipulative skill.[1] Routine work seems to depend largely on specific abilities and their training.

Such tests as packing matches and hitting targets are, of course, comparatively simple. With the greater complexity of most practical work, intelligence undoubtedly becomes more important. The mental age of the subjects tested also affects the significance of the tests. Thus the Form Board described in Experiment LI. is a useful test of intelligence for infants between 5 and 8 or 9 years of age.

Manual dexterity and ability tests are of great importance in vocational selection and guidance.

There are now many more specialised tests involving more apparatus than ours (*e.g.* pegboards, fitting sets of nuts and bolts together), some of which have proved useful in the selection of suitable youths for engineering.[2]

[1] See J. W. Cox, *Manual Skill: Its Nature and Organisation.*

[2] Such tests have been developed especially by the National Institute of Industrial Psychology, from which Dr. Cox's tests may also be obtained.

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The following abbreviations are used:—

B.J.P., IX. 3	British Journal of Psychology, Vol. IX., Part 3.
B.J.Ed.P.	British Journal of Educational Psychology (incorporating The Forum of Education).
B.J.Med P.	British Journal of Medical Psychology.
F.E.	Forum of Education.
A.J.P.	American Journal of Psychology.
J.Ed.P.	Journal of Educational Psychology (American).
J.Ex.P.	Journal of Experimental Psychology.
Ped.Sem.	Pedagogical Seminary: more recently J.Gen.P. . . Journal of Genetic Psychology.
J.Ex.Ped.	Journal of Experimental Pedagogy.
J.Ed.Res.	Journal of Educational Research.
J.N.I.I.P.	Journal of the National Institute of Industrial Psychology: later The Human Factor, and now
O.P.	Occupational Psychology.

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